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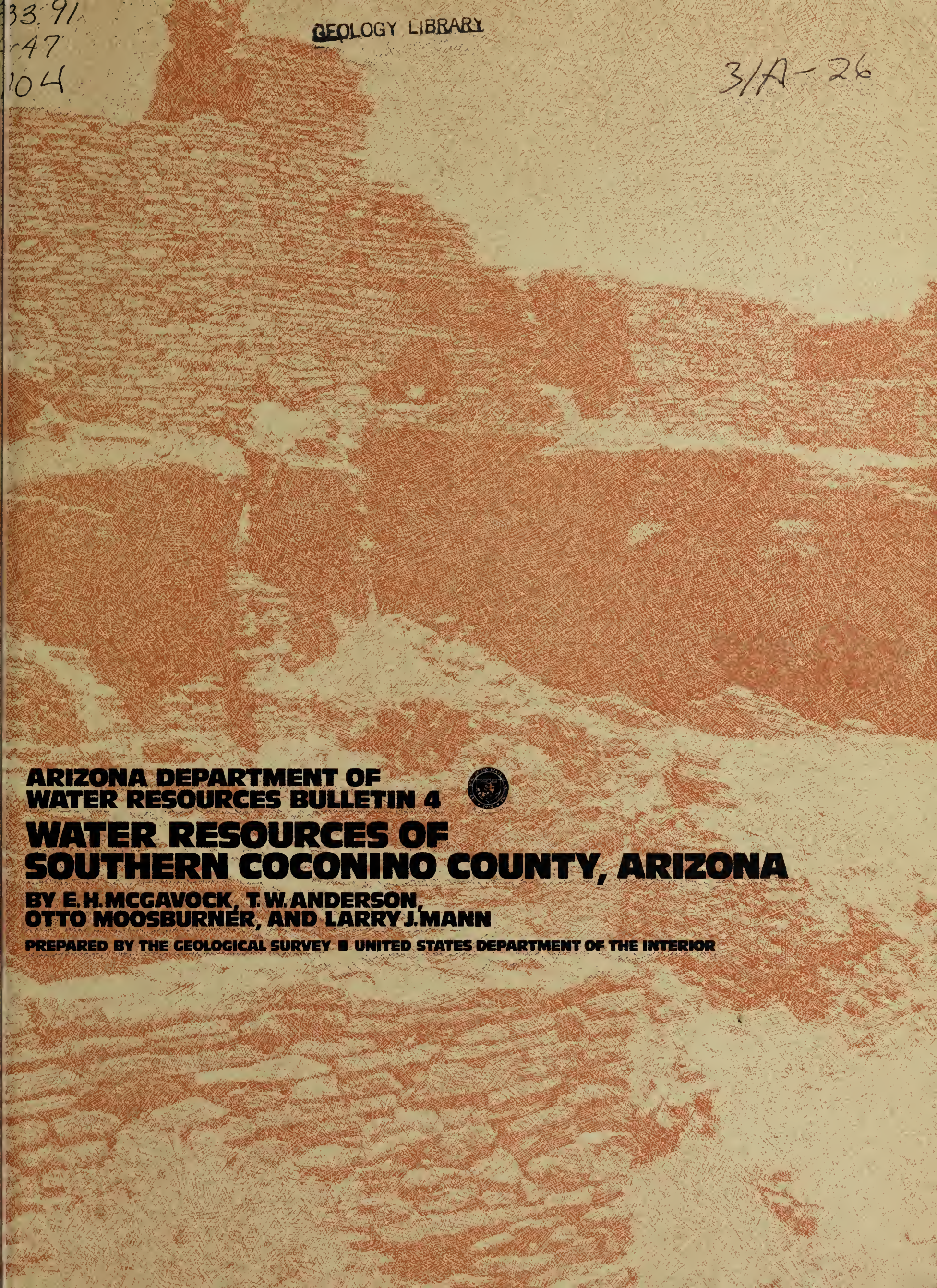

ARIZONA DEPARTMENT OF
WATER RESOURCES BULLETIN 4

# WATER RESOURCES OF SOUTHERN COCONINO COUNTY, ARIZONA

BY E. H. MCGAVOCK, T. W. ANDERSON,
OTTO MOOSBURNER, AND LARRY J. MANN

PREPARED BY THE GEOLOGICAL SURVEY ■ UNITED STATES DEPARTMENT OF THE INTERIOR

## ARIZONA DEPARTMENT OF WATER RESOURCES BULLETINS

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No.

1. Geohydrology and water use in southern Apache County, Arizona, by L. J. Mann and E. A. Nemecek: 86 p., 5 pls., 3 figs., 1983.

2. Appraisal of water resources in the upper Verde River area, Yavapai and Coconino Counties, Arizona, by S. J. Owen-Joyce and C. K. Bell: 219 p., 3 pls., 11 figs., 1983.

3. Hydrology of a stream-aquifer system in the Camp Verde area, Yavapai County, Arizona, by S. J. Owen-Joyce: 60 p., 3 pls., 14 figs., 1984.

4. Water resources of southern Coconino County, Arizona, by E. H. McGavock, T. W. Anderson, Otto Moosburner, and Larry J. Mann: 52 p., 2 pls., 9 figs., 1986.

ARIZONA DEPARTMENT OF WATER RESOURCES
BULLETIN 4

# WATER RESOURCES OF SOUTHERN COCONINO COUNTY, ARIZONA

By
E. H. McGavock, T. W. Anderson, Otto Moosburner, and Larry J. Mann

Prepared by the GEOLOGICAL SURVEY
UNITED STATES DEPARTMENT OF THE INTERIOR

Tucson, Arizona
1986

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# CONVERSION FACTORS

For readers who prefer to use the metric (SI) units, the conversion factors for the terms used in this report are listed below:

| Multiply | By | To obtain |
|---|---|---|
| inch (in.) | 25.4 | millimeter (mm) |
| foot (ft) | 0.3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| acre | 0.4047 | hectare (ha) |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |
| acre-foot (acre-ft) | 0.001233 | cubic hectometer ($hm^3$) |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |
| gallon per minute (gal/min) | 0.06309 | liter per second (L/s) |
| ton (short) | 0.0972 | tonne (t) |
| degree Fahrenheit (°F) | °C = 5/9 (°F-32) | degree Celsius (°C) |

# WATER RESOURCES OF SOUTHERN COCONINO COUNTY, ARIZONA

By

E. H. McGavock, T. W. Anderson, Otto Moosburner,
and Larry J. Mann

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## ABSTRACT

Southern Coconino County includes about 10,600 square miles in north-central Arizona. Water-resources development has been slight, and less than 8,000 acre-feet of ground water and surface water was used in 1975. The amount of ground water in storage is estimated to be between 100 and 200 million acre-feet. The main sources of ground water are the Coconino and limestone aquifers.

The Coconino aquifer includes three principal formations, which in ascending order are the Supai Formation, Coconino Sandstone, and Kaibab Limestone of Pennsylvanian and Permian age. In the southeastern part of the area, the Naco Formation of Pennsylvanian age underlies and intertongues with the lower member of the Supai Formation. The Coconino aquifer furnishes about 75 percent of the ground water used in southern Coconino County, although the aquifer does not underlie the entire area. Depth to water ranges from about 75 feet below land surface near Winslow to about 2,500 feet below land surface north of Flagstaff, and well yields range from about 1 to 1,000 gallons per minute. The chemical quality of the water generally is acceptable for most uses, and dissolved-solids concentrations generally are less than 500 milligrams per liter.

The limestone aquifer consists of a sequence of limestone, dolomite, sandstone, and shale units, which are hydraulically connected. The units, in ascending order, include the Tapeats Sandstone, Bright Angel Shale, and Muav Limestone of Cambrian age; the Temple Butte Limestone, an unnamed limestone unit, and the Martin Formation of Devonian age; the Redwall Limestone of Mississippian age; and an unnamed limestone unit of Pennsylvanian age. The limestone aquifer underlies the entire area and has the greatest water-yielding potential. Because the depth to water is more than 2,500 feet in most places, however, the limestone aquifer generally is not tapped by wells.

In places the Moenkopi and Chinle Formations of Triassic age, volcanic rocks, and sedimentary deposits will yield sufficient water of suitable chemical quality for livestock and domestic uses. Water occurs at depths of less than 300 feet below the land surface, and well yields of 10 to 50 gallons per minute are common.

Streamflow is extremely variable, and most streams are intermittent. Chemical quality of flow in intermittent and perennial streams during medium to high flows generally is acceptable for most uses; dissolved-solids concentrations generally are less than 200 milligrams per liter. Dissolved-solids concentrations in low flows in the perennial streams range from 200 to 2,000 milligrams per liter.

In southern Coconino County about 2,600 acre-feet of ground water and 4,200 acre-feet of surface water was used for public supply and irrigation in 1970. In 1975 about 5,200 acre-feet of ground water was withdrawn and about 2,500 acre-feet of surface water was used. The amount of surface water used annually is dependent on the amount of precipitation and is extremely variable. Ground-water withdrawals have not exceeded the rate of recharge, and water levels have been nearly constant.

# INTRODUCTION

Southern Coconino County includes about 10,600 $mi^2$ in north-central Arizona and is the part of the county south of the Colorado and Little Colorado Rivers (fig. 1). The area includes the Coconino, Kaibab, and Sitgreaves National Forests and part of the Grand Canyon National Park. The steady increase in population, especially near Flagstaff, and the large seasonal influx of people to the recreational areas have caused an increasing demand for water supplies of sufficient quantity and suitable chemical quality. The study was made by the U.S. Geological Survey in cooperation with the Arizona State Land Department and the Arizona Department of Water Resources.

## Purpose and Scope

The purpose of the study was to determine the availability, chemical quality, and use of water in southern Coconino County. The report describes the (1) surface-water characteristics, (2) distribution and general water-yielding characteristics of the aquifers, (3) chemical quality of the water, and (4) amount and effects of water-resources development in 1975. Data for contiguous parts of Yavapai, Navajo, and Gila Counties that relate directly to the hydrology of southern Coconino County are included in the report.

## Methods of Investigation

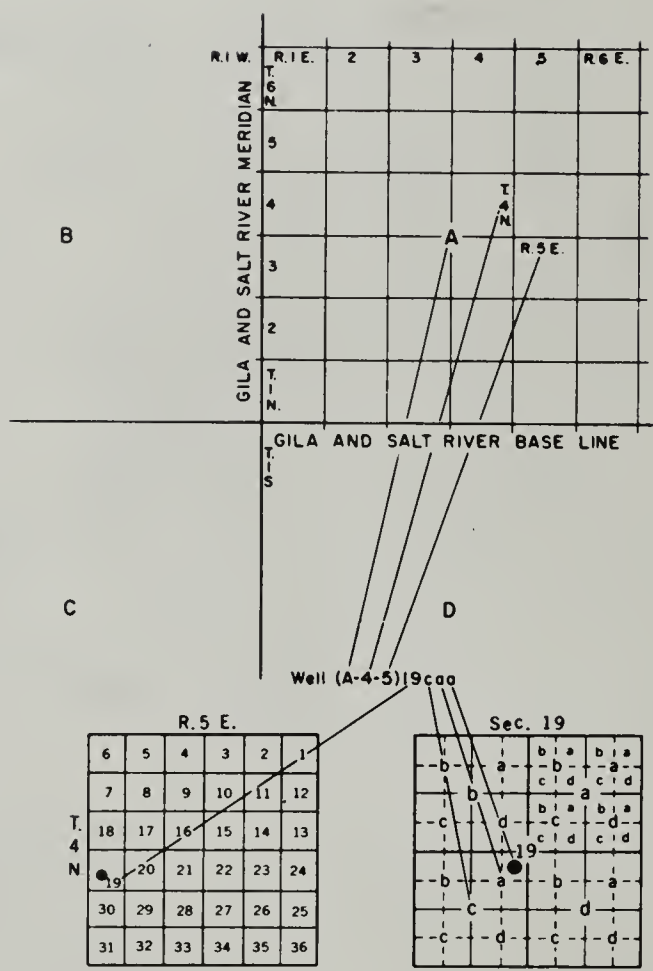
An inventory was made of most wells and springs in the area (McGavock, 1968), and water samples were collected from selected wells, springs, and streams for chemical analysis. Chemical-analysis data are given in tables 4, 5, and 6 at the end of the report. Well and spring

INDEX MAP SHOWING AREA OF REPORT (SHADED)

**Figure 1.--Area of report and Arizona's water provinces.**

locations are described in accordance with the well-numbering system used in Arizona, which is explained and illustrated in figure 2. Lithologic and drillers' logs of wells and drill cuttings were examined to determine the water-yielding potential of the aquifers. A reconnaissance geologic map was compiled from previously published maps to emphasize the aquifers as delineated and discussed in this report.

Records for 39 continuous-record gaging stations and 12 partial-record stations were used to evaluate the surface-water resources of the area. Gaging stations on streams are the most common tool for measuring streamflow; however, gaging every stream is impractical. Certain streamflow characteristics at ungaged sites were estimated by indirect techniques using data transferred from gaged sites. Continuous-record gaging stations provided data for the determination of mean annual flow, flood magnitude and frequency, and low-flow characteristics. Data obtained at crest-stage partial-record gaging stations were used to determine flood magnitude and frequency.




The well numbers used by the Geological Survey in Arizona are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the State into four quadrants. These quadrants are designated counterclockwise by the capital letters A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters a, b, c, and d after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters also are assigned in a counterclockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (A-4-5)19caa designates the well as being in the NE¼NE¼SW¼ sec. 19, T. 4 N., R. 5 E. Where more than one well is within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.

Figure 2.--Well-numbering system in Arizona.

Regionalization of streamflow data provides an estimate of mean annual flow at any site on any stream in most of southern Coconino County (see section entitled "Mean annual flow"). In addition, the probability of a flood of any magnitude from a given drainage-basin size can be estimated. For most of the area, equations have been developed by which the 1-, 3-, and 7-day mean flow volume for a flood having a 50-year recurrence interval may be estimated.

## Previous Investigations

The first detailed geologic study in Coconino County was made in the San Francisco Peaks volcanic field by Robinson (1913). Moore and others (1960) prepared a geologic map of Coconino County, and Cooley (1960) described the geology of the San Francisco Plateau. Geology and water resources of the Navajo Indian Reservation are described in reports by Davis and others (1963), Kister and Hatchett (1963), McGavock and others (1966), and Cooley and others (1964; 1966; 1969). The water resources of other parts of southern Coconino County are discussed by Metzger (1961), Cosner (1962), Twenter (1962), Twenter and Metzger (1963), Levings and Mann (1980), and Levings (1980). Data for many springs in the area are shown in Feth and Hem (1963) and Johnson and Sanderson (1968). Rush (1965) and Beus and others (1966) discussed the relation of geology and surface-water runoff in the Beaver Creek watershed, which is about 30 mi south of Flagstaff. Studies concerning the municipal water supplies for Flagstaff and Williams were made by Akers (1962), Akers and others (1964), and Thomsen (1969). Most of the hydrologic data collected during this investigation were presented by McGavock (1968); selected data collected from 1968 to 1975 are included in this report.

## Acknowledgments

The authors gratefully acknowledge the assistance and cooperation of the well owners and drillers in the area. Valuable information concerning municipal water supplies was provided by H. F. Dunham and J. L. Rawlinson, Water and Sewer Department, city of Flagstaff; R. B. Stinson, city of Winslow; and M. B. McCutchan, Arizona Water Company. W. J. Breed, Museum of Northern Arizona; J. R. Scurlock, State of Arizona Oil and Gas Conservation Commission; and H. E. Brown, U.S. Forest Service, permitted access to their records. K. M. Reim, Chief Mining Engineer for Kern County Land Company, provided well records and geologic maps of the company's holdings in southern Coconino County.

# GEOGRAPHIC SETTING

Nearly all of southern Coconino County is in the Plateau uplands water province of Arizona (fig. 1). The dominant topography is

the north- and northeast-sloping plateau, which is cut by steep-walled canyons. Rolling hills, peaks, and cones of volcanic rocks are superimposed on the plateau, where altitudes generally are from 5,000 to 7,000 ft above sea level. A 250-$mi^2$ area near Flagstaff is underlain by volcanic rocks and is at an altitude of 7,000 to more than 12,500 ft, which is as much as 6,500 ft above the altitude of the surrounding plateau. The Mogollon Rim escarpment has a relief of 2,000 to 3,000 ft and terminates the plateau along its south edge. The steep south-facing slopes of the rim form the demarcation line between the Plateau uplands and Central highlands water provinces of Arizona. Several deeply incised streams breach the Mogollon Rim and drain southward and westward from the plateau. The rim, which is the boundary between Coconino and Gila Counties, is the south boundary of the study area. The study area is further bounded on the south and southwest by Yavapai County and on the west by Mohave County. The Colorado and Little Colorado Rivers form the north and northeast boundaries, respectively, and Navajo County forms the east boundary.

Most streams that drain the area are tributary to the Colorado and Verde Rivers (fig. 1), although a few small areas have interior drainage. The eastern and northeastern parts of the area are drained by the Little Colorado River and its tributaries; the Little Colorado River joins the Colorado River in the Grand Canyon. Havasu and Cataract Creeks drain most of the northwestern part of the area; Havasu Creek is the lower reach of Cataract Creek and joins the Colorado River near the west boundary of Grand Canyon National Park. Between the Little Colorado River and the Coconino-Mohave County line, several small tributaries drain directly to the Colorado River. Tributaries of the south-flowing Verde River drain the southwestern part of the area.

The climate is characterized by extreme temporal and spatial variations in precipitation and temperature. Storms generally move into the area from the south and southwest. In general, the amount of winter precipitation is about equal to the amount of summer precipitation (University of Arizona, 1965a, b). Winter storms commonly distribute low-intensity precipitation over a large area and may last for several days. Major floods occur when rain falls on snow or when rainfall is abnormally intense. During July, August, and September, convectional storms of high intensity but small areal extent and short duration are common. Less frequently, in late summer, large moist airmasses originate off the coast of Mexico and deposit heavy rains that last from 1 day to several days; these infrequent and intense storms cause major floods.

The mean annual precipitation ranges from less than 6 in. along the Little Colorado River to more than 35 in. along the Mogollon Rim and on the San Francisco Peaks (fig. 3). The distribution of the precipitation is influenced by the orographic effect of the Mogollon Rim. At the Sedona Ranger Station at the base of the Mogollon Rim, the mean annual precipitation is 17.15 in. (Sellers and Hill, 1974, p. 460). About 50 mi north of the rim at Winslow, which is at about the same altitude as the Sedona station, the mean annual precipitation is 7.37 in. (Sellers and Hill, 1974, p. 570) The local orographic effects of the San Francisco

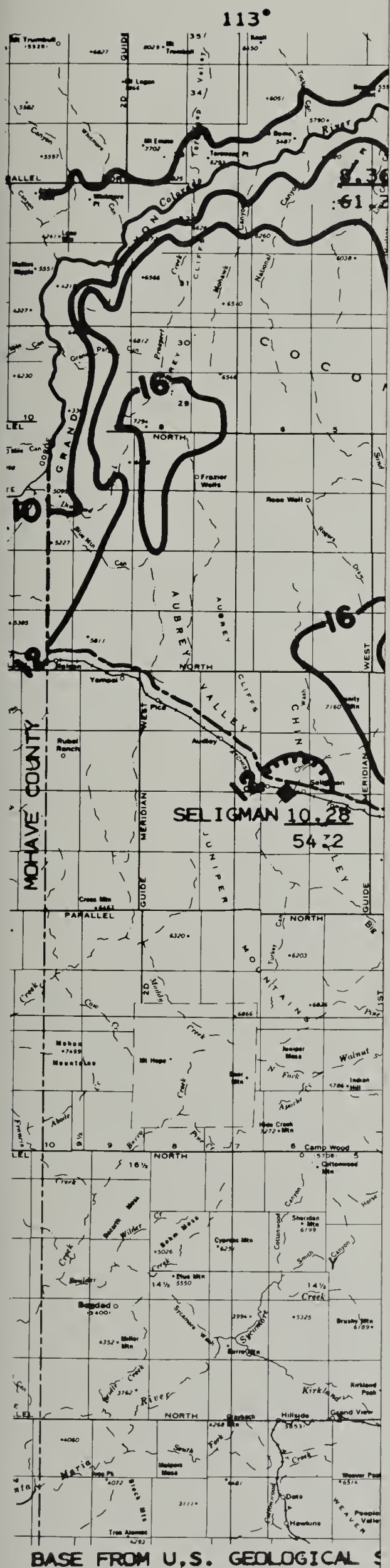



Figure 3.

## EXPLANATION

12 — LINE OF EQUAL MEAN ANNUAL PRECIPITATION—Interval 2, 4, and 5 inches. Hachured to indicate closed areas of lower precipitation. Data from University of Arizona (1965a, b)

21.21 / 49.7 — WEATHER STATION—Upper number, 21.21, is mean annual precipitation in inches; lower number, 49.7, is mean annual temperature in degrees Fahrenheit. Data from Sellers and Hill (1974)

10 0 10 20 30 40 MILES

10 0 10 20 30 40 50 KILOMETERS

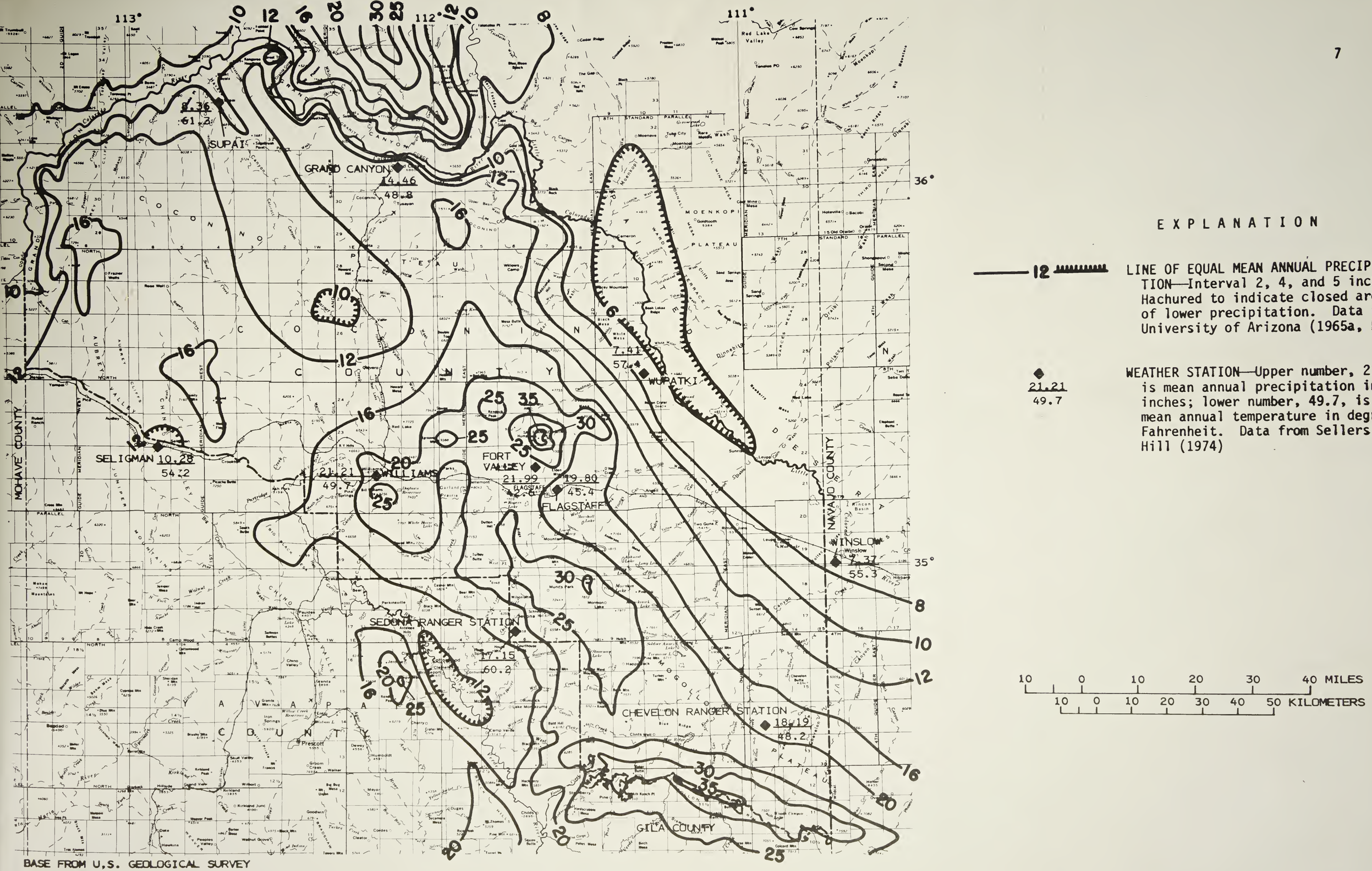



Figure 3.--Mean annual precipitation, 1931-60, and mean annual temperature, 1941-70.

Peaks and Bill Williams Mountain cause greater precipitation at Flagstaff, Fort Valley, and Williams than at about the same altitude at the Grand Canyon (fig. 3). Mean annual snowfall ranges from less than 10 in. along the Colorado and Little Colorado Rivers to more than 80 in. in the areas of highest altitude along the Mogollon Rim and the San Francisco Peaks. The mean annual temperature ranges from about 40°F at altitudes above 8,000 ft to about 60°F along the Colorado and Little Colorado Rivers. Mean annual temperatures at selected weather stations in or adjacent to the study area also are shown in figure 3.

## SURFACE WATER

Most of the precipitation in the area evaporates, is transpired by plants, flows to the Colorado and Verde Rivers, or infiltrates to the underlying ground-water reservoirs. A small part of the precipitation is stored in natural or manmade impoundments for municipal, livestock, or recreational use. Nearly all streams in the study area are intermittent and flow only in response to rainfall or snowmelt; a few streams contain perennial flow that is maintained by ground-water discharge. A significant but unknown amount of streamflow percolates through the streambeds and recharges ground-water reservoirs.

### Mean Annual Flow

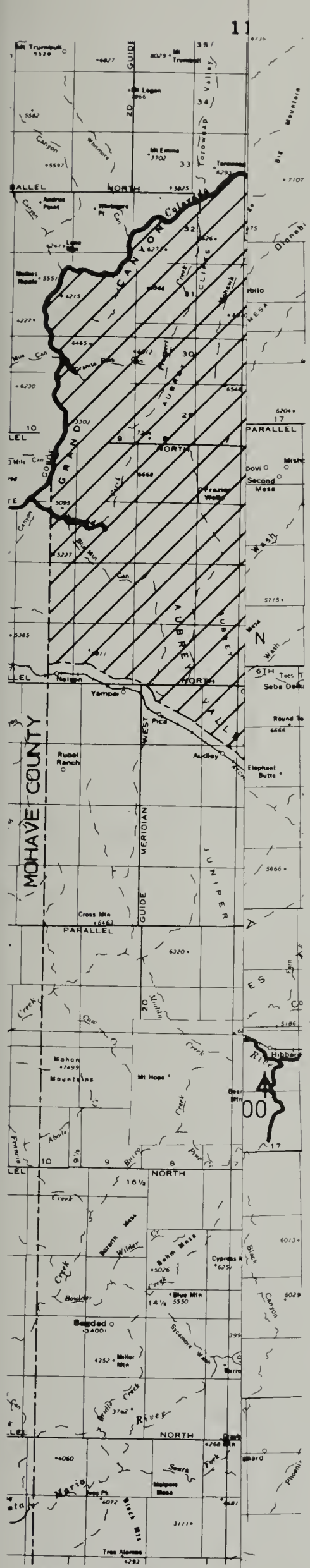
Data from 39 continuous-record gaging stations having 5 years or more of record show the large variation in flow in the area and the variation in flow at a station with time (table 1). The coefficient of variation (table 1) is a measure of annual flow variability—the larger the value, the larger the variability. A zero value would indicate constant flow. Data collected at crest-stage gaging stations further indicate the variability of flow and the small amount of runoff. Results indicate that zero flow occurred in about 50 percent of the years at these sites. The infrequent flow events typically are less than a few hours in duration. Additional and more detailed daily streamflow data including monthly and annual flow totals and low- and peak-flow data are published annually (U.S. Geological Survey, 1919-60; 1961-75).

A multiple-regression technique was used to regionalize mean annual flow. Measurements of basin and climatic characteristics, such as drainage area, slope of the stream, mean annual precipitation, and snowfall in gaged basins, are treated as independent variables and are related to various dependent streamflow characteristics, such as mean annual flow. A study by Moosburner (1970) using data collected at 104 streamflow sites throughout Arizona provided a method for estimating mean annual flow in part of southern Coconino County on the basis of regionalization of the data. The data for all streamflow-gaging stations (fig. 4) in southern Coconino County and adjacent areas were handled in a similar manner to provide a method for estimating the mean annual flow in most

Table 1.--Mean flow characteristics at continuous-record gaging stations

| Station number | Station name | Period of record | Drainage area, in square miles | Mean flow: Cubic feet per second | Mean flow: Acre-feet per year[1] | Mean flow: Inches per year | Mean flow: Standard error, in percent | Maximum yearly flow, in acre-feet[1] | Minimum yearly flow, in acre-feet[1] | Coefficient of variation |
|---|---|---|---|---|---|---|---|---|---|---|
| 09397500 | Chevelon Creek below Wildcat Canyon, near Winslow..... | 1947-70 | 275 | 49.5 | 35,860 | 2.44 | 14 | 95,490 | 9,610 | 0.66 |
| 09398000 | Chevelon Creek near Winslow..... | 1917-19, 1930-33, 1936-72 | 794 | 50.3 | 36,440 | .86 | 9 | 105,300 | 5,560 | .63 |
| 09398500 | Clear Creek below Willow Creek, near Winslow..... | 1947-74[2] | 321 | 78.7 | 57,020 | 3.33 | 16 | 201,800 | 7,620 | .82 |
| 09399000 | Clear Creek near Winslow..... | 1930-33, 1936-74[2] | 607 | 77.7 | 56,290 | 1.74 | 13 | 196,500 | 5,050 | .83 |
| 09400600 | Rio de Flag at Flagstaff..... | 1956-60 | 50.4 | .15 | 109 | .04 | 102 | 531 | 0 | 2.28 |
| 09400850 | Upper Lake Mary near Flagstaff..... | 1949-70 | 53.5 | 9.21 | 6,670 | 2.34 | 19 | 17,500 | 0 | 0.82 |
| 09401000 | Little Colorado River at Grand Falls..... | 1925-51, 1953-59 | 21,200 | 253 | 183,200 | .16 | 12 | 586,800 | 18,670 | .72 |
| 09402000 | Little Colorado River near Cameron..... | 1948-74[2] | 26,500 | 228 | 165,200 | .12 | 18 | 815,900 | 19,340 | .93 |
| 09404040 | Cataract Creek near Williams..... | 1966-72 | 46.4 | 3.10 | 2,250 | .91 | 43 | 7,750 | 344 | 1.14 |
| 09503700 | Verde River near Paulden..... | 1964-74[2] | 2,530 | 33.7 | 24,420 | .18 | 14 | 55,340 | 17,330 | .47 |
| 09503720 | Hell Canyon near Williams.... | 1966-72 | 14.9 | 3.31 | 2,400 | 3.02 | 29 | 5,090 | 216 | .78 |
| 09503800 | Volunteer Wash near Bellemont..... | 1966-72 | 131 | 3.82 | 2,770 | .40 | 33 | 6,040 | 0 | .89 |
| 09504000 | Verde River near Clarkdale..... | 1915-16, 1917-20 1965-74[2] | 3,520 | 193 | 139,800 | .74 | 17 | 306,300 | 60,960 | .58 |
| 00504500 | Oak Creek near Cornville..... | 1941-45 1949-74[2] | 357 | 83.4 | 60,420 | 3.17 | 11 | 173,600 | 21,440 | .60 |
| 09505200 | Wet Beaver Creek near Rimrock..... | 1962-74[2] | 111 | 32.6 | 23,620 | 3.99 | 22 | 74,500 | 6,400 | .81 |
| 09505250 | Red Tank Draw near Rimrock..... | 1958-74[2] | 49.4 | 7.18 | 5,200 | 1.97 | 31 | 26,740 | 32 | 1.29 |
| 09505300 | Rattlesnake Canyon near Rimrock..... | 1958-74[2] | 24.6 | 7.29 | 5,280 | 4.02 | 27 | 21,720 | 100 | 1.11 |
| 09505350 | Ory Beaver Creek near Rimrock..... | 1961-74[2] | 142 | 37.4 | 27,100 | 3.58 | 27 | 97,940 | 990 | 1.01 |
| 09505800 | West Clear Creek near Camp Verde..... | 1966-74[2] | 241 | 59.8 | 43,300 | 3.37 | 32 | 143,800 | 13,330 | .97 |
| | U.S. Forest Service gaging stations | | | | | | | | | |
| | Beaver Creek Watershed 1.... | 1958-73 | 0.52 | 0.04 | 30.5 | 1.10 | 35 | 140 | 0 | 1.38 |
| | Beaver Creek Watershed 2.... | 1958-74[2] | .20 | .01 | 10.4 | 1.00 | 36 | 53 | 0 | 1.49 |
| | Beaver Creek Watershed 3.... | 1958-74[2] | .57 | .04 | 32.2 | 1.07 | 36 | 177 | 0 | 1.49 |
| | Beaver Creek Watershed 4.... | 1958-73 | .54 | .21 | 152 | 5.29 | 26 | 608 | 5.4 | 1.02 |
| | Beaver Creek Watershed 5.... | 1958-73 | .10 | .04 | 29.0 | 5.28 | 28 | 128 | .8 | 1.14 |
| | Beaver Creek Watershed 6.... | 1959-73 | 0.16 | .04 | 31.5 | 3.64 | 31 | 144 | .5 | 1.21 |
| | Beaver Creek Watershed 7.... | 1958-73 | 3.18 | .71 | 515 | 3.03 | 27 | 2,099 | .6 | 1.08 |
| | Beaver Creek Watershed 8.... | 1958-74[2] | 2.82 | 1.41 | 1,024 | 6.82 | 22 | 3,465 | 78 | .89 |
| | Beaver Creek Watershed 9.... | 1958-74[2] | 1.75 | .90 | 649 | 6.95 | 23 | 2,384 | 26 | .96 |
| | Beaver Creek Watershed 10.... | 1958-74[2] | .89 | .28 | 205 | 4.31 | 28 | 872 | 3.7 | 1.16 |
| | Beaver Creek Watershed 11.... | 1959-74[2] | .29 | .07 | 49.2 | 3.14 | 30 | 227 | .2 | 1.22 |
| | Beaver Creek Watershed 12.... | 1959-74[2] | .71 | .36 | 258 | 6.81 | 25 | 1,046 | 7.3 | 1.00 |
| | Beaver Creek Watershed 13.... | 1959-74[2] | 1.42 | .38 | 274 | 3.61 | 25 | 1,072 | 28 | 1.00 |
| | Beaver Creek Watershed 14.... | 1959-74[2] | 2.11 | .72 | 519 | 4.61 | 28 | 2,295 | 10 | 1.11 |
| | Beaver Creek Watershed 15.... | 1963-74[2] | .25 | .08 | 54.5 | 4.01 | 29 | 155 | .1 | 1.00 |
| | Beaver Creek Watershed 16.... | 1963-74[2] | .39 | .17 | 126 | 6.00 | 27 | 426 | 7.3 | .95 |
| | Beaver Creek Watershed 17.... | 1963-74[2] | .47 | .28 | 205 | 8.24 | 25 | 631 | 20 | .82 |
| | Beaver Creek Watershed 18.... | 1963-74[2] | .38 | .18 | 132 | 6.56 | 25 | 389 | 6.0 | .87 |
| | Beaver Creek Watershed 19.... | 1962-74[2] | 16.71 | 7.58 | 5,490 | 6.16 | 27 | 19,440 | 167 | . 97 |
| | Beaver Creek Watershed 20.... | 1962-74[2] | 25.75 | 11.3 | 8,160 | 5.94 | 26 | 28,810 | 244 | .94 |

[1]Based on water year, October 1 through September 30.
[2]Active gaging station.




hern Coconino County.

EXPLANATION

RUNOFF REGIONS

Region 1

Region 2

Region 3

402000 — STREAMFLOW-GAGING STATION—Number is abbreviated station number; see station number 09402000 on table 1

503800 — DISCONTINUED STREAMFLOW-GAGING STATION NUMBER—Number is abbreviated station number; see station number 09503800 on table 1

PERENNIAL STREAM REACH—Small reaches of only local significance are not shown

10 0 10 20 30 40 MILES

10 0 10 20 30 40 50 KILOMETERS

BASE FROM U.S. GEOLOGICAL SURVEY

Figure 4.--Perennial stream reaches, location of streamflow-gaging stations, and runoff regions in southern Coconino County.

of the study area. As a result of the data analysis, southern Coconino County was divided into three runoff regions (fig. 4). The applicable equations for regions 1 and 2 are:

Region 1: $Q = 1.30 \times 10^{-6} A^{0.77} P^{3.94}$

and

Region 2: $Q = 5.09 \times 10^{-5} A^{0.82} P^{2.76} S^{0.41}$,

where

Q = mean annual flow, in cubic feet per second;
A = drainage area, in square miles;
P = normal annual precipitation on the drainage area, in inches; and
S = shape factor, defined as the square of the length of main channel from site to divide, in miles, divided by the drainage area, in square miles.

The third region is an area largely underlain with volcanic cinders north of Flagstaff where surface-water runoff may be negligible. A regression equation could not be defined for this region because data are insufficient. The regression equations should be used with judgment and in conjunction with other procedures, such as those recommended by Moore (1968), and with correlation methods whenever possible.

The Colorado River is almost completely regulated by releases from Glen Canyon Dam near the Arizona-Utah State line (fig. 1). Tributary inflow from the Paria and Little Colorado Rivers and some smaller streams represent the only uncontrolled flow. Before 1963 when regulation by Glen Canyon Dam began, the mean annual flow of the Colorado River near Grand Canyon for 1922-62 was 16,930 $ft^3/s$ and ranged from a high of 26,840 $ft^3/s$ in 1929 to a low of 6,431 $ft^3/s$ in 1934. Most of the flow occurred from April to July from snowmelt in the upper Colorado River basin. For 1964-74, which included the period when Lake Powell was filling, the flow averaged 12,840 $ft^3/s$.

The greatest surface-water unit runoff in the study area is from the Mogollon Rim area where the normal annual precipitation is greater than 20 in. (fig. 3). Mean annual runoff of as much as 8.24 in. has been measured from small high-altitude drainages in the Mogollon Rim area by the U.S. Forest Service (table 1). Mean annual runoff from larger watersheds—greater than 10 $mi^2$—tributary to the Verde River and the upper reaches of Clear and Chevelon Creeks ranges from 1.97 to 6.16 in. (table 1). Runoff is least in the area of the volcanic cinders north of Flagstaff, in some of the low-altitude and comparatively flat parts of the Havasu drainage, and along the Little Colorado River. The mean annual surface-water runoff in these areas probably is much less than 0.5 in. and may be near zero. The lowest surface-water runoff measured at a gaging station in the study area—0.04 in./yr—was for Rio de Flag at Flagstaff (table 1).

## Flood Peaks

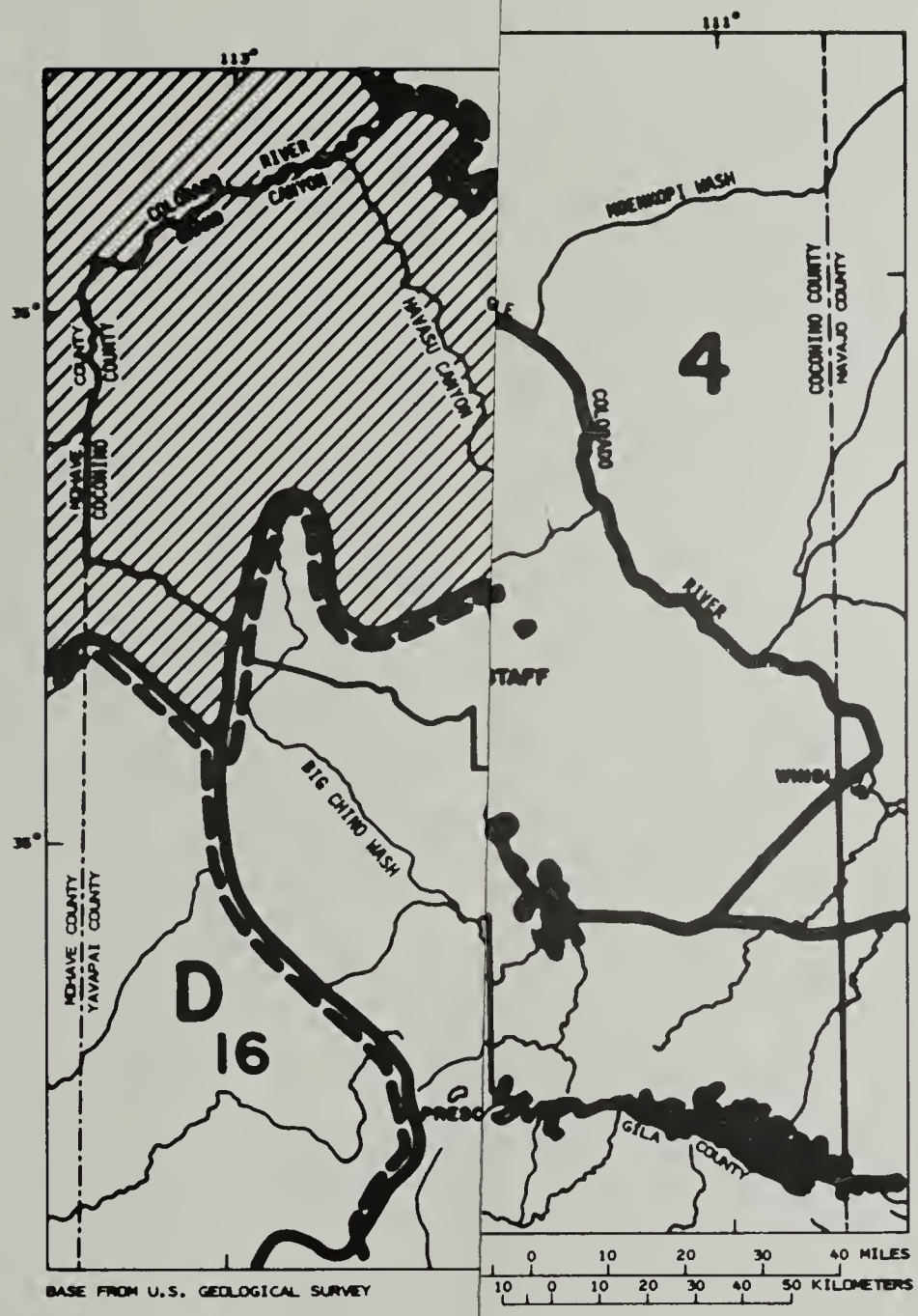
Flood discharges and frequency of occurrence in the area are reported as peak instantaneous discharges, flood volume for a specified period of time, and flow duration. These data must be known for proper design of hydraulic structures, highways, and storage projects; floodway zoning; and other purposes where consideration of water supply or flood hazard is a factor.

Flood-peak frequency data for a site commonly are plotted as peak discharge versus recurrence interval. Recurrence interval is defined as the average interval of time within which a peak flow of a given magnitude will be equaled or exceeded once. The probability of a flood of a given magnitude occurring in any one year may be estimated from a given recurrence interval. For example, if the recurrence interval of a flood of a given magnitude is 25 years, the probability of it occurring in any one year is 4 percent. Although the average frequency of a flood of a given magnitude can be estimated, the time of its next occurrence cannot be predicted.

Flood-peak frequencies can be determined directly from flow records for a specific site where streamflow is gaged. Regionalization of the data involves combining the frequency curves developed for individual gaging stations in a region into one frequency curve that would be applicable to any stream in a region at either a gaged or ungaged site. By assuming that the data can be regionalized, an inherent assumption of homogeneity is made with respect to flood-producing characteristics within the region.

The three hydrologic areas and two flood-frequency regions defined by Patterson and Somers (1966) that are included in southern Coconino County are shown in figure 5A. The index method is one method of regionalizing the flood-peak frequency curve. Peak discharges that have a recurrence interval of 2.33 years ($Q_{2.33}$), which is defined as the mean annual flood, are utilized in developing two relations. One is the relation of the mean annual flood to the size of the drainage area from which the floods originate. The relations for each of the hydrologic areas are shown in figure 6. The second relation uses the dimensionless ratio of any discharge to the mean annual flood to relate to recurrence interval. The relations for the two flood-frequency regions are shown in figure 7. The combined use of these two relations allows the estimation of the peak discharge of a flood of any recurrence interval at any stream site in the region where the flood-frequency relations are defined.

Roeske (1978) used multiple-regression techniques to develop regional flood-frequency relations based on gaging-station data collected throughout Arizona. Equations were presented for estimating peak-flow magnitudes for recurrence intervals of 2, 5, 10, 25, 50, 100, and 500 years (Roeske, 1978, p. 5-7). The study area includes parts of




N

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HIGH-ELEVATION

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D FL ION

FL ION BOUNDARY

17 HY

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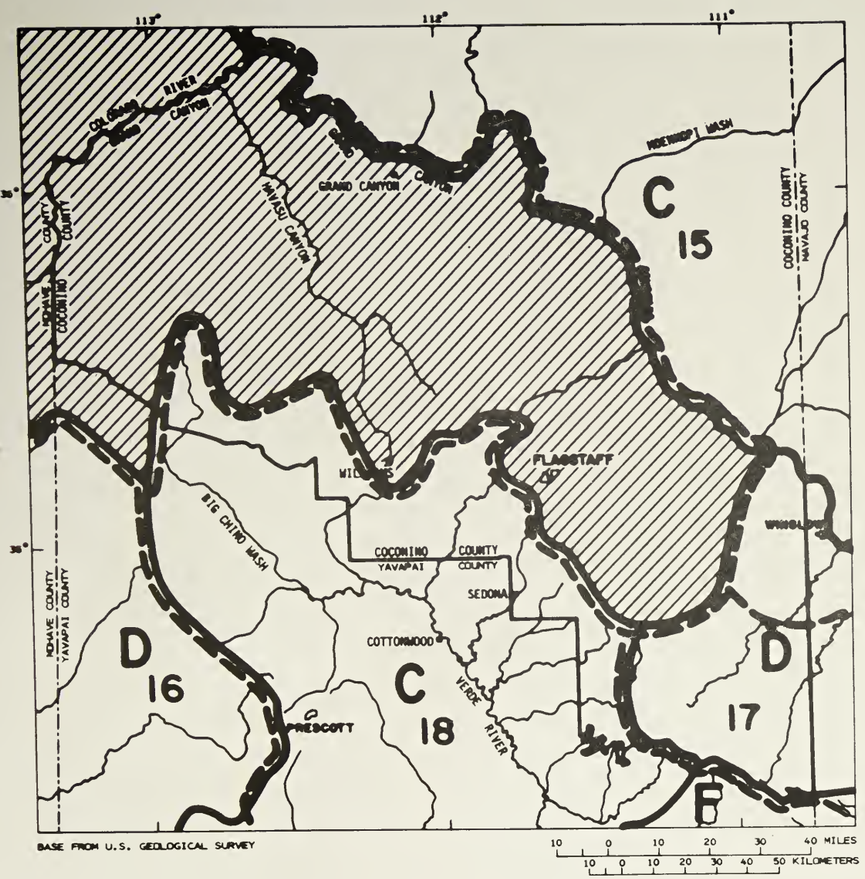
Roeske (1978).

A. Flood-freq
of Patter

Figure 5.--Hydrologic a




EXPLANATION

FLOOD-FREQUENCY RELATIONS NOT DEFINED

D FLOOD-FREQUENCY REGION

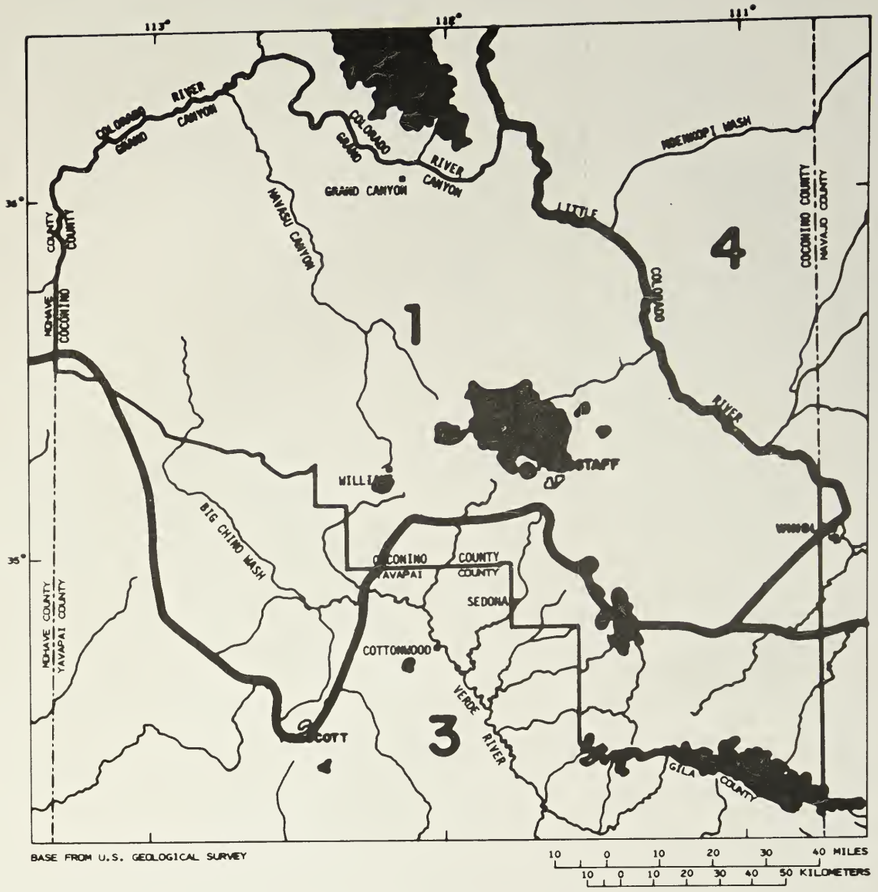
FLOOD-FREQUENCY REGION BOUNDARY

17 HYDROLOGIC AREA

HYDROLOGIC-AREA BOUNDARY

STUDY-AREA BOUNDARY

A. Flood-frequency regions and hydrologic areas of Patterson and Somers (1966, pl. 1).




EXPLANATION

APPROXIMATE AREA OF HIGH-ELEVATION FLOOD-FREQUENCY REGION

4 FLOOD-FREQUENCY REGION

FLOOD-FREQUENCY REGION BOUNDARY

STUDY-AREA BOUNDARY

B. Flood-frequency regions of Roeske (1978).

Figure 5.--Hydrologic areas and flood-frequency regions in southern Coconino County.

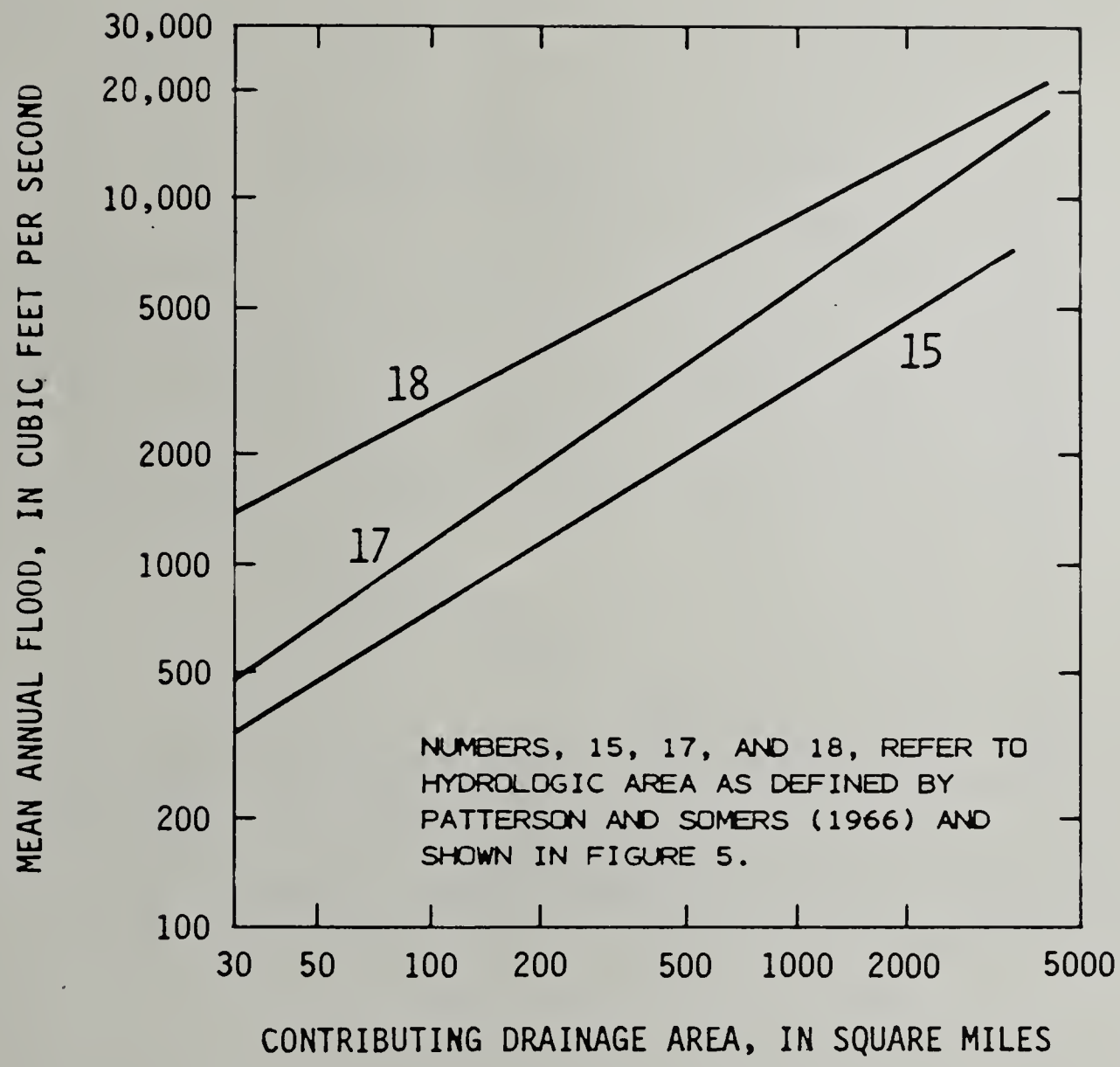



Figure 6.--Drainage area versus mean annual flood (Patterson and Somers, 1966, p. 12).

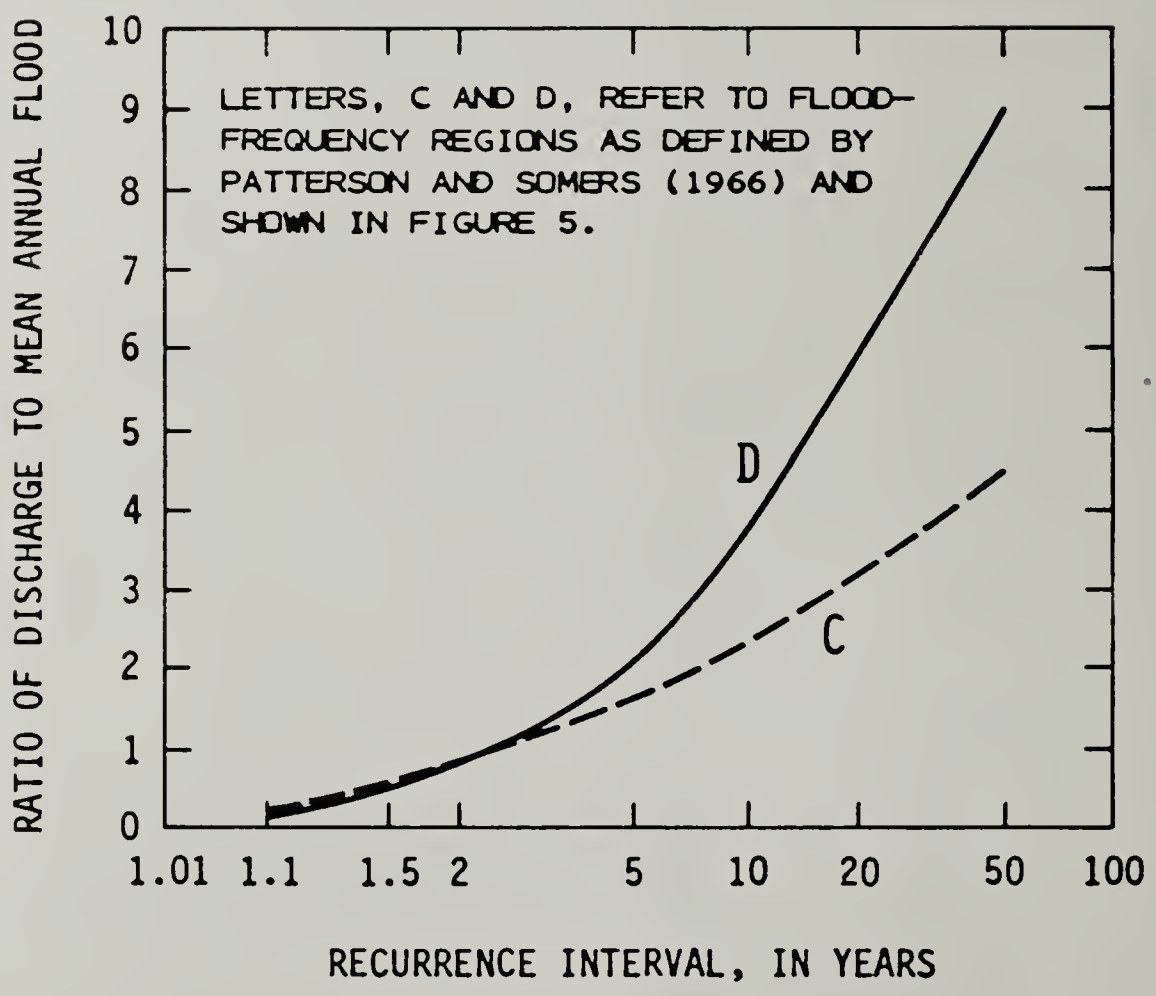



Figure 7.--Ratio of T-year flood to mean annual flood ($Q_{2.33}$) (Patterson and Somers, 1966, p. 4).

Roeske's Region 1—Northwest plateau area, Region 3—Central mountain area, Region 4—Northeast plateau area, and the high-elevation region (fig. 5B).

## Flood Volumes

The relation of flood volumes for various flow durations and recurrence intervals was determined from a regression analysis of the data from gaged streams in the study area. The equations that resulted from the analyses are given in table 2. The equations are applicable to runoff regions 1 and 2 (fig. 4); no equation was determined for region 3. The 1-, 3-, and 7-day mean flow volumes for a 50-year recurrence interval can be estimated for ungaged stream sites in most of the area by use of the equations in table 2.

## Flow-Duration Curves

A flow-duration curve for a stream site is a cumulative frequency curve that shows the percentage of time that specified discharges are equaled or exceeded (Searcy, 1959, p. 1). The curve combines the flow characteristics of a stream site throughout the range of discharge without regard to the sequence of occurrence and provides a convenient means for comparing streams. The slope of the flow-duration curve is indicative of the hydrologic and geologic characteristics of a drainage area.

Representative flow-duration curves for selected perennial and intermittent streams in the study area are shown in figure 8. Chevelon Creek near Winslow and Oak Creek near Cornville are perennial at the gage sites; this is indicated by the flat-slope part of the curve to the right (fig. 8). The intermittent streams are illustrated by the steep slope of the curve and the lack of a flat-slope part. Although duration curves are not available for small intermittent streams typical of the northwestern part of the study area, crest-stage gaging-station data indicate that flow occurs only about 1 percent of the time when a time unit of a day is used. The percentage of time in most places probably is less than 1 percent because each flow event encompasses only a few hours rather than a full day.

## Perennial Streams and Low Flows

Only a few streams in or near the study area are perennial. The known perennial reaches are shown in figure 4, exclusive of the small perennial spring-fed streams tributary to the Colorado River in the Grand Canyon and a few reaches of minor streams of only local significance. Ground-water discharge is the source of water in the perennial streams.

Table 2.--Regression equations used to estimate 1-, 3-, and 7-day mean flow volumes on ungaged streams in runoff regions 1 and 2 for a 50-year recurrence interval

[Runoff region is shown in figure 4. $V_{1,50}$, $V_{3,50}$, and $V_{7,50}$ are the highest 1-, 3-, and 7-day mean flow volumes that occur on the average of once every 50 years; A is drainage area, in square miles. P is mean annual precipitation in drainage area, in inches. I is maximum 24-hour point rainfall, in inches, having a recurrence interval of 10 years (U.S. Weather Bureau, 1967). SO is the soil index, which is dimensionless; the soil index is an index to the capacity of the soil to accept infiltration and is based on soil type, soil cover, and agriculture practices. An index of 3 generally should be used in southern Coconino County except in the Grand Canyon area, where 4 should be used and in some parts of the Flagstaff area where the index is 2]

| Region 1 | | Region 2 | |
|---|---|---|---|
| Mean flow, in cubic feet per second | Standard error, in percent | Mean flow, in cubic feet per second | Standard error, in percent |
| $V_{1,50} = 0.582A^{0.65}I^{4.34}$ | 104 | $V_{1,50} = 1.76\ A^{0.80}I^{-.78}(SO)^{3.68}$ | 67 |
| $V_{3,50} = 0.331A^{0.67}I^{4.21}$ | 86 | $V_{3,50} = 1.01\ A^{0.82}I^{-.73}(SO)^{3.56}$ | 55 |
| $V_{7,50} = 0.254A^{0.65}I^{4.09}$ | 74 | $V_{7,50} = 9.34 \times 10^{-2}A^{0.83}P^{0.97}(SO)^{-0.80}I^{2.62}$ | 47 |

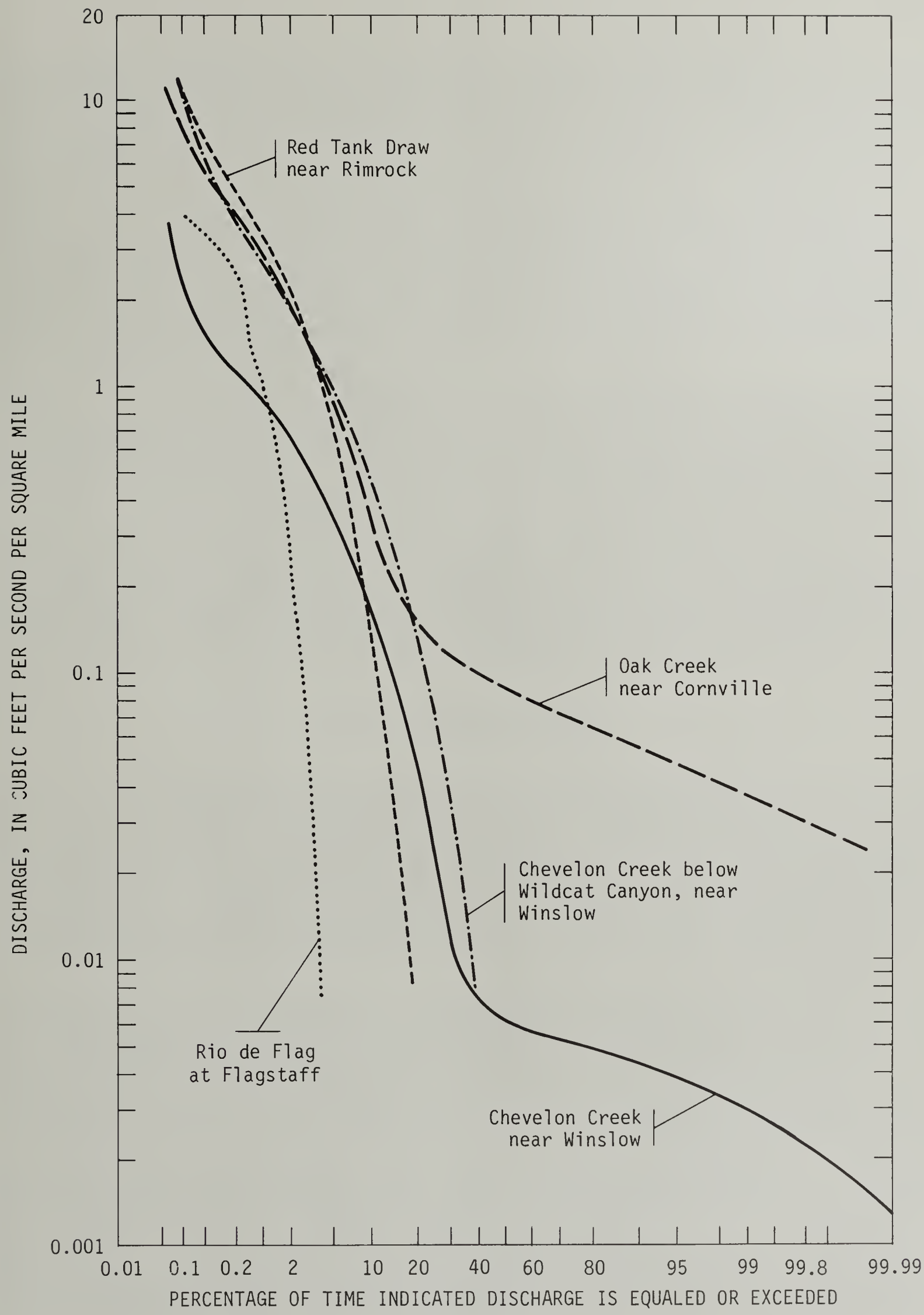



Figure 8.--Flow-duration curves for selected streamflow-gaging sites.

The perennial streams in the Little Colorado River drainage in or near the study area include (1) parts of Chevelon Creek, which has a low-flow rate of 3,260 acre-ft/yr at the gaging station Chevelon Creek near Winslow; (2) parts of Clear Creek, which has a low-flow rate of 3,100 acre-ft/yr downstream from the gaging station Clear Creek near Winslow (Mann, 1976); and (3) the Little Colorado River from Blue Spring to its mouth, which has a low-flow rate of 161,000 acre-ft/yr. Blue Spring is the largest of several springs that issue into the Little Colorado River from about 3 to 13 mi above its mouth. This is the only reach of the Little Colorado River in the study area that is perennial. Thirteen discharge measurements made from 1952 to 1967 indicate that little variation occurs in the total spring flow (Johnson and Sanderson, 1968).

Havasu Spring is the source of perennial flow in Havasu Creek. The spring is a series of seeps that emerge from the bottom of Havasu Canyon along several branches of Havasu Creek. The seeps occur in a quarter-mile reach about 10 mi upstream from the mouth of Havasu Creek. Discharge measurements made downstream from Havasu Spring since 1950 indicate a nearly constant base flow of about 46,000 acre-ft/yr.

Several spring-fed tributaries to the Verde River, which include Oak Creek, Wet Beaver Creek, and West Clear Creek, head and are perennial in a part of the study area. Additional information on springs in or near the study area is presented by Feth and Hem (1963) and Johnson and Sanderson (1968).

## Quality of Surface Water

Most of the dissolved constituents in streamflow are derived from reactions of rainfall or snowmelt with minerals on the surface of the ground or in the ground. A smaller component is contained in the rain and snow prior to its contact with the ground surface. At the same sampling site in a stream, concentrations of dissolved solids will be greater in the base flow than in the floodflow. Owing to the longer ground-contact time, base-flow water dissolves more minerals than does floodflow water.

Dissolved-solids concentrations in streamflow during periods of storm or snowmelt runoff are extremely low in most streams that drain the area. The concentrations range from 34 to 916 mg/L (milligrams per liter) and generally are less than 100 mg/L (table 4). The main dissolved-solids constituents during the high-runoff periods are silica, calcium, and bicarbonate.

The base flow of the Little Colorado River below Blue Spring and in the lower reaches of Chevelon Creek contains from 1,870 to 2,600 mg/L or more of dissolved solids (table 4); the main constituents are sodium and chloride. Flow of Havasu Creek below the springs generally has a dissolved-solids concentration that ranges from 380 to 485 mg/L (table 4); the main constituents are calcium and bicarbonate. The

chemical quality of the base flow of the Verde River tributaries is markedly better than that of the Colorado River and its tributaries. The dissolved-solids concentrations range from 153 mg/L in Wet Beaver Creek to 220 mg/L in Oak Creek; the main constituents are calcium and bicarbonate (table 4).

Stream temperatures (table 4) are dependent mainly on air temperature, size of the stream, and proximity of the measuring site to the streamflow source. Storm and snowmelt runoff temperatures probably are closely related to local air temperatures, whereas streamflow temperatures immediately downstream from perennial springs are nearly constant, especially below springs that are the outflow from large ground-water reservoirs.

Streamflow transports disintegrated rock material either in suspension or as bedload. The sediment load of any stream depends on the characteristics of the drainage basin, such as lithology, vegetal cover, mean annual precipitation, storm intensity, topography, and type and degree of development. The sediment yield, which is the volume of sediment load per unit area, varies widely in the study area and generally is lowest in the highest altitudes (W. F. Mildner, Soil Conservation Service, written commun., 1971). Quantitative data are sparse for most streams, but floodflow in the Little Colorado River at Cameron transported a total of 2,580,000 tons of suspended sediment on September 21, 1952 (Love, 1961, p. 155).

## GROUND WATER

Ground water occurs in nearly all the geologic formations that underlie southern Coconino County and is the major source of reliable water supplies. Many of the geologic formations are hydraulically connected and combine to form aquifers. An aquifer is a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs (Lohman and others, 1972, p. 2).

On the basis of subsurface geologic data from wells and test holes, two major aquifers are delineated in southern Coconino County. The Coconino aquifer is the uppermost and main source of ground water in the eastern part of the area. In the central and western parts of the area, the Coconino aquifer generally does not contain water. Water occurs mainly in a sequence of hydraulically connected limestone, dolomite, and sandstone units that are found at considerable depth below the units that make up the Coconino aquifer. Because the rocks that form the deeper aquifer are mainly limestone, the aquifer is informally referred to as the "limestone aquifer."

In addition to the widespread occurrence of water in the Coconino and limestone aquifers, ground water also occurs in the Moenkopi and Chinle Formations, volcanic rocks, and sedimentary

deposits. Although these units do not contain water over large areas, they do provide locally important sources of water mainly for domestic and livestock use.

## Coconino Aquifer

The Coconino aquifer is the main source of ground water in the eastern part of the study area. West of Flagstaff, the units that make up the aquifer generally are drained of water. The aquifer consists of three principal formations, which, in ascending order, are the Supai Formation of Permian and Pennsylvanian age and the Coconino Sandstone—the main water-bearing unit in the aquifer—and the Kaibab Limestone of Permian age (pl. 1). In the southeastern part near Fossil Creek, the Naco Formation of Pennsylvanian age underlies and intertongues with the lower member of the Supai Formation. No wells are known to tap the Naco, but the Naco is the source of Fossil Springs, which discharge about 18,000 gal/min of water. In the central part of the area the Toroweap Formation of Permian age separates the Coconino Sandstone from the Kaibab Limestone. In the northwestern part the Hermit Shale of Permian age lies between the Supai Formation and the Coconino Sandstone. Where the Toroweap and Hermit are present, they generally are above the water table.

The Supai Formation is the thickest and most lithologically variable formation in southern Coconino County. The formation is about 800 ft thick at the west end of the Grand Canyon, 1,750 ft thick along the Mogollon Rim in Fossil Creek Canyon (Huddle and Dobrovolny, 1945), and 2,200 ft thick near Winslow. In the northwestern part the Supai is overlain by the Hermit Shale and consists of alternating beds of silty sandstone and siltstone.

In the central and southeastern parts of the area, three distinct members of the Supai have been recognized. The upper member of the Supai is composed of moderately silty sandstone that in places intertongues with the overlying Coconino Sandstone. The middle member is composed of alternating beds of siltstone and mudstone with some sandstone, conglomerate, and limestone. The lower member of the Supai is mainly sandstone, siltstone, and limestone. Part of the lower member is lithologically similar to and may be the lateral equivalent of the Naco Formation that underlies the Supai east of Verde Valley (Twenter and Metzger, 1963, p. 30).

In the extreme northeastern part of the area, the upper member of the Supai is mainly a very fine grained sandstone and silty sandstone that grades downward into mainly siltstone. The siltstone impedes the downward movement of water into the underlying limestone aquifer. As the Supai is traced east and south, however, the siltstone beds grade laterally into very fine grained sandstone and silty sandstone. The siltstone beds are fractured along major faults and folds, such as the Oak Creek and Anderson Mesa faults, the Tolchaco anticline, and the East

Kaibab monocline. The fractures provide a direct hydraulic connection between the Coconino aquifer and the deeper limestone aquifer, and water in the Coconino aquifer moves downward into the limestone aquifer. In places, such as near Sedona, the Coconino and limestone aquifers probably function as a single hydraulic unit (Levings, 1980).

In the northwestern part of the area, no wells produce water from the Supai Formation. The sandstone in the upper 500 ft of the unit however is an important source of water in the rest of the area, especially near Flagstaff. The alternating beds of sandstone, limestone, siltstone, and mudstone in the middle and lower members presently are the chief source of ground water in the Sedona area.

The Hermit Shale is about 930 ft thick near the Grand Canyon, thins rapidly to the south and east, and is not recognizable near the towns of Williams or Cameron. The Hermit is composed of very fine grained sandstone, silty sandstone, and limestone and does not yield water to wells in the area. The Hermit may perch water in the overlying Coconino Sandstone in places where the sandstone is commonly drained of water.

The Coconino Sandstone is the most productive and wide-spread unit of the Coconino aquifer in southern Coconino County. The Coconino is a very fine to medium-grained, cross-bedded sandstone that is moderately to well cemented. The Coconino is about 900 ft thick along the Mogollon Rim near Pine and near Wupatki National Monument and thins to about 100 ft thick at the west end of Grand Canyon National Park. The Coconino Sandstone is only moderately to poorly permeable in the study area except where it is well jointed or faulted.

The Toroweap Formation in the Grand Canyon area is composed of about 375 ft of limestone, siltstone, sandstone, and some gypsum beds. Southeastward, toward Flagstaff, the Toroweap thins and becomes principally a sandstone; the formation is not recognizable east of the Flagstaff area. The Toroweap is rarely water bearing in the study area except near Grand Canyon Village where the siltstone beds perch water in overlying sandstone beds.

The Kaibab Limestone is composed of sandy limestone and dolomite and is uniform in lithology throughout most of the area. The thickness of the Kaibab generally increases in a northwesterly direction from about 50 ft near Winslow to 380 ft near the Grand Canyon. In places, especially in canyon areas, the Kaibab has been completely removed by erosion. The Kaibab Limestone generally is highly fractured; thus, it readily accepts recharge from precipitation and allows downward percolation of water into underlying formations. The Kaibab generally is above the water table except for small areas near the Little Colorado River where it is hydraulically connected with the underlying Coconino Sandstone. Near Flagstaff, chert beds and dense limestone beds locally perch water in overlying beds of jointed limestone.

## Occurrence and Movement of Water

The occurrence and movement of water in the Coconino aquifer are controlled to a large extent by the lithology, or composition, of the rock units that make up the aquifer. The occurrence and movement of ground water in the northwestern and southeastern parts of the study area are discussed separately because of the difference in lithology and because the two areas are hydrologically distinct with respect to ground-water characteristics.

Mogollon Rim-Flagstaff area.--The Mogollon Rim-Flagstaff area includes the eastern and southern parts of southern Coconino County and corresponds with the western limit of the Coconino aquifer (pl. 2). The Coconino aquifer in this area includes the Kaibab Limestone, the Coconino Sandstone, the Supai Formation, and, in a small area near the Mogollon Rim, the Naco Formation.

Recharge to the aquifer occurs primarily in the areas of high precipitation, which generally are at altitudes above 7,000 ft along the Mogollon Rim. Precipitation in these areas readily infiltrates in outcrop areas of fractured limestone, sandstone, and volcanic rocks and percolates downward into the Coconino aquifer.

Ground-water movement in the Mogollon Rim-Flagstaff area is to the northeast or to the southwest. A ground-water divide, which approximately coincides with the principal recharge area, occurs near the Mogollon Rim (pl. 1). Much of the ground water moving southward and westward from the divide is discharged as springs and seeps along the Mogollon Rim and provides the source of base flow in the tributaries to the Verde River. The largest single discharge point, Fossil Springs, discharges about 18,000 gal/min from the Naco Formation at the base of the aquifer. Some water in the Coconino aquifer percolates downward along fracture zones into the underlying limestone aquifer and eventually discharges to the Verde River.

In most of the Mogollon Rim-Flagstaff area, water in the Coconino aquifer moves northeastward away from the ground-water divide near the Mogollon Rim and generally flows toward the Little Colorado River (pl. 1). Near the river, however, the direction of movement changes abruptly to the northwest. This change in direction of movement is influenced by at least three factors: (1) recharge to the aquifer occurs along the channel of the Little Colorado River and causes a local mound that underlies the river; (2) ground water moves into the study area from Navajo County (Mann, 1976) and then moves northwestward along the Little Colorado River; and (3) a major discharge area for the Coconino aquifer is along the faulted East Kaibab monocline and the Mesa Butte fault system (pl. 1). Ground water percolates downward along this fault and fracture zone into the underlying limestone aquifer. The ultimate area of discharge for this water is the group of springs in a

10-mile reach in the canyon of the Little Colorado River beginning at Blue Spring about 13 mi upstream from the mouth.

Ground water in the Coconino aquifer is unconfined in nearly all the Mogollon Rim-Flagstaff area. In a small area between Winslow and Leupp, ground water occurs under artesian conditions because the aquifer is fully saturated and is confined by the overlying Moenkopi Formation.

Grand Canyon-Williams area.--The Grand Canyon-Williams area comprises about 6,000 $mi^2$ in the northwestern part of the study area. In this area the Coconino aquifer includes two formations—the Toroweap Formation and Hermit Shale—not recognized in the Mogollon Rim-Flagstaff area and does not include the Naco Formation. The Coconino aquifer is dry throughout most of the Grand Canyon-Williams area; only three wells completely penetrate the Coconino aquifer. The area of highest precipitation, and presumably the greatest recharge potential, is near Williams. However, two deep holes that completely penetrated the Coconino aquifer—one near Ash Fork and one about 20 mi north of Williams—were dry during drilling until the Redwall Limestone was penetrated. Records for an oil test in sec. 35, T. 28 N., R. 1 W., indicate that the aquifer was penetrated fully, but hydrologic data are not available. The siltstone beds of the Toroweap Formation and the Hermit Shale are not present in the area near Williams, and the rest of the Coconino aquifer apparently is sufficiently permeable to allow downward percolation of ground water into the underlying limestone aquifer.

Some water is present in the Coconino aquifer in the northern part of the area near the Grand Canyon owing to the presence of fine-grained perching beds. Water is perched in the Coconino Sandstone by the underlying Hermit Shale. The reported saturated thickness of the Coconino Sandstone in wells drilled into this perched water zone ranges from about 10 to 120 ft. Most wells however penetrated 50 to 60 ft of water-bearing sandstone above the Hermit Shale. Near Tusayan, 6 mi south of Grand Canyon Village, several wells reportedly yield from 0.5 to 4.5 gal/min from fractured limestone interbedded with siltstone in the Toroweap Formation.

## Availability of Water

The depth to water in the Coconino aquifer in the Mogollon Rim-Flagstaff area ranges from about 75 ft near Winslow to about 2,500 ft below the land surface north of Flagstaff. The formations that compose the Coconino aquifer are dry in most of the Grand Canyon-Williams area; deep wells tap the limestone aquifer in which the depth to water is believed to be at least 3,000 ft below the land surface. Near Cataract Creek and Tusayan where the Coconino aquifer contains perched water, the depth to water is about 950 ft and 550 ft below the land surface, respectively.

Well yields from the Coconino aquifer range from about 1 gal/min where the sandstone has a high degree of cementation and the saturated thickness is a few tens of feet to about 1,000 gal/min where the aquifer is extensively fractured and has a saturated thickness of more than 250 ft. The yield of a properly constructed well depends on the saturated thickness and the hydraulic conductivity of the aquifer near the well site. The hydraulic conductivity is a function of the degree of interconnection of open space in the aquifer material. Some of the open space is between grains in sandstone aquifers, but cracks and fissures created by faulting and jointing increases the hydraulic conductivity in the Coconino aquifer.

The city of Flagstaff well fields at Woody Mountain and at Lake Mary are in or near fault zones; these wells yield from 200 to 1,000 gal/min and are some of the most productive wells in southern Coconino County. The fault zones also may provide a highly permeable drain for ground water. Sterling Spring at the head of Oak Creek Canyon is on the Oak Creek fault and its flow is maintained by ground-water discharge from the Coconino aquifer.

## Chemical Quality of Water

In most of the study area, water in the Coconino aquifer contains less than 500 mg/L of dissolved solids and is suitable for most uses. In the southern and central parts of the Mogollon Rim-Flagstaff area, the dissolved-solids concentrations in the water range from about 100 to 500 mg/L (pl. 2), and the principal constituents are calcium and bicarbonate. In the northern part of the Mogollon Rim-Flagstaff area, near the Little Colorado River, the water contains from 500 to as much as 7,640 mg/L dissolved solids; the principal constituents are sodium and chloride. Chemical analyses of the water from many of the wells in the area were published by McGavock (1968). The ranges and median values of the major dissolved constituents are shown in table 3; analyses of the water from selected springs and wells also are included in tables 5 and 6.

Table 3.--Range and median value of dissolved constituents in water from selected aquifers

[Analytical results in milligrams per liter except as indicated]

| Aquifer | Silica ($SiO_2$) | Iron (Fe) in solution at time of analysis | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$ | Specific conductance (micromhos at 25°C) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volcanic rocks | | | | | | | | | | | | | | |
| Range ..... | 20-67 | 0.0-0.14 | 12-82 | 6.8-24 | 2.8-17 | | 84-262 | 3-34 | 2-44 | 0.0-0.4 | 124-324 | 70-282 | 174-623 | 6.8-8.1 |
| Median value .... | 37 | 0.00 | 2.25 | 11 | 8.6 | | 124 | 10 | 8 | 0.2 | 160 | 100 | 242 | 7.2 |
| Number of analyses ..... | 14 | 11 | 16 | 16 | 16 | | 16 | 16 | 16 | 16 | 14 | 16 | 16 | 14 |
| Coconino aquifer | | | | | | | | | | | | | | |
| Range ..... | 5.2-56 | 0.00-0.18 | 14-229 | 4.1-96 | 0.7-2,600 | | 66-890 | 0.0-667 | 1-4,200 | 0.0-1.0 | 66-7,640 | 52-834 | 107-12,900 | 6.8-8.2 |
| Median value .... | 13 | 0.01 | 76 | 40 | 29 | | 240 | 134 | 51 | 0.2 | 551 | 353 | 846 | 7.5 |
| Number of analyses ..... | 97 | 62 | 130 | 129 | 123 | | 119 | 120 | 123 | 127 | 112 | 122 | 115 | 95 |

The general distribution of total dissolved solids in ground water in the Coconino aquifer is shown on plate 2. In some areas, specific-conductance values were used to estimate dissolved-solids concentrations.

Specific conductance is a measure of the ability of ions to conduct an electrical current and is a general indication of the amount of dissolved material in the water. An estimate of the dissolved solids can be made by multiplying the specific conductance by a factor that generally ranges from 0.55 to 0.75. On the basis of 108 measurements of both parameters in the study area, the ratio of dissolved solids to specific conductance in water from the Coconino aquifer is 0.60.

In the Mogollon Rim-Flagstaff area, ground water is mostly of the calcium magnesium bicarbonate type and generally contains less than 500 mg/L dissolved solids (pl. 2). The calcium, magnesium, and bicarbonate are derived from recharge areas near Flagstaff and along the Mogollon Rim where the water percolates downward through the Kaibab Limestone and then moves northeastward or southwestward through sandstone that contains little soluble material. The chemical quality of the water is fairly uniform except for that in an area that extends about 5 to 20 mi southwestward from the Little Colorado River where a sodium chloride type water dominates (pl. 2). The source of the sodium and chloride is halite deposits in the Supai Formation 10 to 80 mi east of the study area (Akers, 1964, p. 80; Mann, 1976, p. 17).

The chemical quality of water does not change significantly with depth of penetration into the Coconino aquifer in the southwestern three-quarters of the Mogollon Rim-Flagstaff area. In Navajo County east of the study area, the chemical quality of water generally deteriorates with depth in areas where the aquifer contains water of a sodium chloride type (Mann, 1976). Along the Little Colorado River where sodium chloride water is present, a similar deterioration with depth probably occurs (pl. 2).

During this study, samples of water from the Coconino aquifer were collected at 14 wells that had been sampled 10 to 33 years previously. No significant change in chemical quality with time was found except in four of the wells in the Winslow municipal well field (table 6). The principal change in the quality of the water from these wells was an increase in the sodium and chloride concentrations. Analyses of water from city of Winslow well No. 1 collected in 1953 and again in 1966 indicate an increase in dissolved solids from 531 to 1,040 mg/L; the sodium concentration increased from 79 to 249 mg/L, and the chloride concentration increased from 92 to 410 mg/L. Similar changes in water quality occurred in three other wells. In the fifth well no change in quality was noted. The reason for the changes in water quality is not known. It is postulated, however, that the relatively heavy pumping is causing saline water to move into the well field, either vertically from greater depths in the aquifer or from the east and northeast as a result of local alteration of the regional hydraulic gradient. The chemical quality of water in this area may continue to deteriorate as a result of the influence of this local cone of depression.

## Limestone Aquifer

The limestone aquifer consists of several hydraulically connected limestone, dolomite, sandstone, and shale units. The units, in ascending order, include the Tapeats Sandstone, Bright Angel Shale, and Muav Limestone of Cambrian age; the Temple Butte Limestone, an unnamed limestone unit, and the Martin Formation of Devonian age; the Redwall Limestone of Mississippian age; and an unnamed limestone unit of Pennsylvanian age (pl. 1). In most of the area, the Redwall Limestone is the uppermost unit of the aquifer and is about 2,500 ft below the land surface. The unit is exposed in the Grand Canyon, along the Mogollon Rim, and in a small area west of Aubrey Valley. The combined thickness of the units that make up the aquifer generally increases from southeast to northwest. Three of the units included in the aquifer are present only in parts of the area. The unnamed limestone units of Devonian and Pennsylvanian age are present in and near the Hualapai Indian Reservation, and the Temple Butte Limestone is present in the eastern part of the Grand Canyon.

### Occurrence and Movement of Water

The limestone aquifer underlies all of southern Coconino County but crops out only in the extreme northern and western parts of the area. Thus, most of the water in the aquifer is derived from the downward movement of water from the overlying Coconino aquifer. In the eastern part of the area, a thick sequence of siltstone in the overlying Supai Formation impedes the downward movement of water from the Coconino aquifer. In the central part of the area, however, the Supai is largely a very fine grained sandstone interbedded with siltstone. The sandstone, particularly where fractured, is more permeable than the siltstone and allows the water to move downward. Much of the water probably moves downward into the limestone aquifer along major fracture zones, such as the Oak Creek fault and East Kaibab monocline, and possibly along the Mesa Butte fault system (pl. 1).

Storage and movement of water is primarily in fractures and solution channels in the carbonate rocks—mainly limestone and dolomite. Water is also stored in fractures and intergranular pore spaces in the Tapeats Sandstone and in sandstone beds in the other units. In the northern part of the study area, the Bright Angel Shale at the base of the carbonate rocks in the aquifer and above the Tapeats Sandstone impedes the downward movement of water. In the Grand Canyon many springs issue from solution cavities in limestone and dolomite that overlie the Bright Angel Shale.

The limestone aquifer may be nearly or completely saturated in most of the area east of Flagstaff where the lower part of the overlying Coconino aquifer is saturated. Water in the limestone aquifer may be confined in places by siltstone in the overlying Supai and Naco Formations

but probably is unconfined in most or all the area between Williams and the Grand Canyon. In the Sedona area, the Coconino and limestone aquifers are hydraulically connected in highly fractured areas such as the Oak Creek fault zone and combine to form a regional aquifer (Levings, 1980).

The direction of ground-water movement in the limestone aquifer can be only inferred from points of spring discharge and from wells south of the study area. A large part of the ground water probably moves northward toward springs along the Little Colorado and Colorado Rivers and Havasu Creek. South of Williams, ground water probably moves southward toward discharge areas along the Verde River. The location of the ground-water divide in the western part of the area is unknown owing to the extreme paucity of data; however, the continuance of the limestone aquifer is assumed. The principal discharge points of the limestone aquifer are Havasu Spring along Havasu Creek and springs in a 10-mile reach in the canyon of the Little Colorado River beginning at Blue Spring about 13 mi upstream from the mouth. Blue Spring and the other springs along the Little Colorado River have a combined flow of about 220 $ft^3/s$ or about 100,000 gal/min. A large part of this flow however represents ground water from the Coconino aquifer, which moves downward into the limestone aquifer through the sandstone and fractured siltstone of the Supai Formation.

Havasu Spring is about 10 mi above the mouth of Havasu Creek (pl. 2) and discharges about 64 $ft^3/s$ or about 29,000 gal/min (Johnson and Sanderson, 1968, p. 17) from the unnamed limestone unit of Pennsylvanian age at the top of the limestone aquifer. The altitude of the springs is about 3,250 ft, which is nearly 1,000 ft below the bottom of any water well in the northern part of the area. A significant amount of ground water also may move out of the area to the south. The base flow in the Verde River increases by about 50 $ft^3/s$ in a 25-mile reach south of Williams. A large but unknown part of this water may be discharging from the area north of the river.

Blue Spring may be associated with small faults below the foot of the East Kaibab monocline. Cooley (1976, p. 9) concluded that ground-water movement occurs through the highly fractured zone along and near the East Kaibab monocline. Other faults in the study area, especially the Aubrey, Toroweap, and Hurricane faults, may exert a similar influence on local ground-water conditions.

## Availability of Water

In most of southern Coconino County, ground water in the limestone aquifer is beyond an economical well depth for most purposes. The Redwall Limestone is 2,500 to 3,000 ft below the land surface in most of the area east of Flagstaff. Because water generally is available in overlying shallower units, few wells penetrate the limestone aquifer. In most of the western part, the top of the Redwall Limestone is about 2,200 to

2,500 ft below the land surface. The Redwall and some of the other carbonate units that overlie the Bright Angel Shale may be dry in much of the area. Depth to water in the limestone aquifer therefore is expected to be about 3,000 ft below the land surface throughout most of this part of the study area. Between Chino Point and the Mohave County line where the units that form the aquifer crop out, depth to water ranges from 625 ft below the land surface near Chino Point to about 800 ft at Pica, which is south of the study area in Aubrey Valley.

The yields of wells that penetrate the limestone aquifer are expected to be highly variable and unpredictable from place to place. Where the limestone and dolomite of the aquifer are relatively unfractured, the hydraulic conductivity is low and well yields may be 25 gal/min or less. Where the limestone and dolomite are fractured, especially if the fractures are enlarged by solution, the hydraulic conductivity is high and well yields of 1,000 gal/min or more are possible.

In 1976, only one well in southern Coconino County was withdrawing water from the limestone aquifer. This well, about 20 mi north of Williams, produced about 5 gal/min of water from the Redwall Limestone at a depth of 2,800 ft. After the well was deepened to the Tapeats Sandstone, about 20 gal/min of water was produced from a pumping level of about 3,000 ft below the land surface. At Pica, several wells reportedly yield 50 to 145 gal/min of water from the limestone aquifer. Southwest of Sedona, some wells penetrate the Redwall Limestone at a depth of about 1,000 ft. Water levels in these wells range from 600 to 800 ft below the land surface; well yields are reported to range from 20 to 1,000 gal/min.

## Chemical Quality of Water

The water from springs that discharge from the limestone aquifer along Havasu Creek, the Colorado River, and tributaries of the Verde River generally is of acceptable chemical quality for most uses. The dissolved-solids concentrations range from 282 to 623 mg/L, and the principal constituents are calcium, magnesium, and bicarbonate (table 5). The dissolved-solids concentrations in the water from two wells that penetrate the aquifer west of Sedona were 355 and 451 mg/L (McGavock, 1968, p. 44). The water from other wells that penetrate the limestone aquifer southwest of Sedona and south of Aubrey Valley is acceptable for public, domestic, and stock use. Levings (1980) showed that the dissolved-solids concentrations of water from wells that tap the Redwall Limestone generally are less than 500 mg/L; analyses are not available for wells south of Aubrey Valley. The water from the well about 20 mi north of Williams that taps the limestone aquifer is unfit for most uses. Specific conductance of the water is 20,200 micromhos, and the dissolved-solids concentration is 12,400 mg/L; sodium and chloride are the major constituents (table 6). Most of the water is produced from the upper part of the Tapeats Sandstone.

Springs that discharge from the limestone aquifer in the lower reaches of the Little Colorado River yield water in which the dissolved-solids concentrations range from 2,320 to about 24,380 mg/L (table 5). The principal constituents of the water from Blue Spring are sodium, calcium, bicarbonate, and chloride. The ratio of sodium chloride to calcium bicarbonate in the water downstream from Blue Spring increases until, at a point 3.1 mi above the mouth of the Little Colorado River, the water is predominantly of the sodium chloride type. Si-Pa-Po Spring (pl. 1) discharges water that contains 24,380 mg/L dissolved solids, principally sodium and chloride. Several small "salt springs" issue from the Tapeats between Blue Spring and mile point 3.1. The source of the sodium chloride probably is the halite deposits in the Supai Formation, which are 10 to 80 mi east of the southern Coconino County area.

## Other Aquifers

In places, ground water can be obtained from units that overlie the Coconino aquifer. The Moenkopi and Chinle Formations, volcanic rocks, and sedimentary deposits locally will yield quantities of water adequate for domestic and livestock use. The occurrence and quantity of water that can be developed cannot be ascertained on the basis of areal distribution of the units nor on existing data but are dependent on the lithology of the unit, the presence of fractures, and the lithology of the underlying formations. If the underlying formations are permeable sandstone or fractured limestone, the water generally moves downward into the Coconino or limestone aquifers. If the units are underlain by siltstone, which is relatively impermeable and impedes the downward movement of water, the units may contain perched ground water.

### Moenkopi and Chinle Formations

The Moenkopi Formation includes an interbedded sequence of siltstone, mudstone, silty sandstone, and gypsum. The Moenkopi is overlain by the Chinle Formation, which is mainly siltstone and mudstone with sandstone and conglomerate near the base (pl. 1). The combined thickness of the Moenkopi and Chinle Formations of Triassic age is about 800 ft.

The Moenkopi and Chinle Formations generally are not water bearing but yield some water to wells in three small areas. Three wells in the Slate Mountain-Cedar Ranch area extend through volcanic rocks into sandstone that may be part of the Chinle Formation. No change in water level was reported after drilling through the volcanic rocks, therefore the sandstone probably is water bearing and is hydraulically connected to the overlying volcanic rocks. Several wells near Fort Valley are reported to yield 5 to 15 gal/min from fractured silty sandstone in the Moenkopi Formation. Northwest of Winslow, several wells yield water from the Moenkopi; reported yields range from 1 to 20 gal/min. The Moenkopi

and Chinle may yield water in other places, but subsurface data are inadequate to assess this possibility.

One chemical analysis of water from the Chinle Formation was available and none for water from the Moenkopi Formation. The water sample from the Chinle is from a dug well in the extreme northeastern part of the study area—well (A-27-10)6abc. The dissolved-solids concentration in the water is 766 mg/L, and the major constituents are sodium, bicarbonate, and sulfate (McGavock, 1968, table 4). Water from wells thought to penetrate the Chinle and Moenkopi Formations in the Fort Valley and the Slate Mountain-Cedar Ranch areas is reportedly of acceptable chemical quality for domestic use. Water from the Moenkopi Formation near Winslow, where the Moenkopi contains gypsum beds, is reported to be of unacceptable chemical quality and normally is cased out of wells.

## Volcanic Rocks

The volcanic rocks consist of basalt flows, cinder cones and beds, and tuff beds. These rocks are as much as 1,000 ft thick, excluding the volcanic mountains such as San Francisco Peaks and Bill Williams Mountain. The occurrence and availability of water in the volcanic rocks are extremely variable and unpredictable. Some of the variation may be due to seasonal recharge, differences in well-drilling and construction methods, and to a limited extent, the techniques used to estimate the well yields. Much of the variability however is due to the extent of local fracturing in the rocks and to the openness of the fractures.

About 50 wells have been drilled into volcanic rocks in the Fort Valley area near Flagstaff. Well yields range from 0.5 to about 15 gal/min during sustained pumping. Well depths generally are from 100 to 200 ft, and water levels are from 20 to 170 ft below the land surface. Six producing wells have been drilled into volcanic rocks in the Slate Mountain-Cedar Ranch area. Water levels in these wells are from 85 to 375 ft below the land surface, and well depths are from 112 to 450 ft; well yields reportedly range from about 10 to 100 gal/min. Water supplies have also been developed from volcanic rocks near Mormon Lake, in Spring Valley, and at the Navajo Army Depot at Bellemont. Generally, the wells are less than 250 ft deep and produce 1 to 20 gal/min of water.

Water samples from 14 wells that tap only the volcanic rocks contain from 124 to 324 mg/L of dissolved solids. Calcium and bicarbonate are the dominant ions (table 5).

## Sedimentary Deposits

The sedimentary deposits include alluvial deposits and glacial moraine and outwash. They are composed of silt, clay, sand, and gravel

and boulders of Quaternary and Tertiary age. The greatest known thickness of the deposits is in Aubrey Valley where an oil-test hole penetrated 420 ft of sand, gravel, and clay. In most places, however, the deposits are from 50 to 100 ft thick.

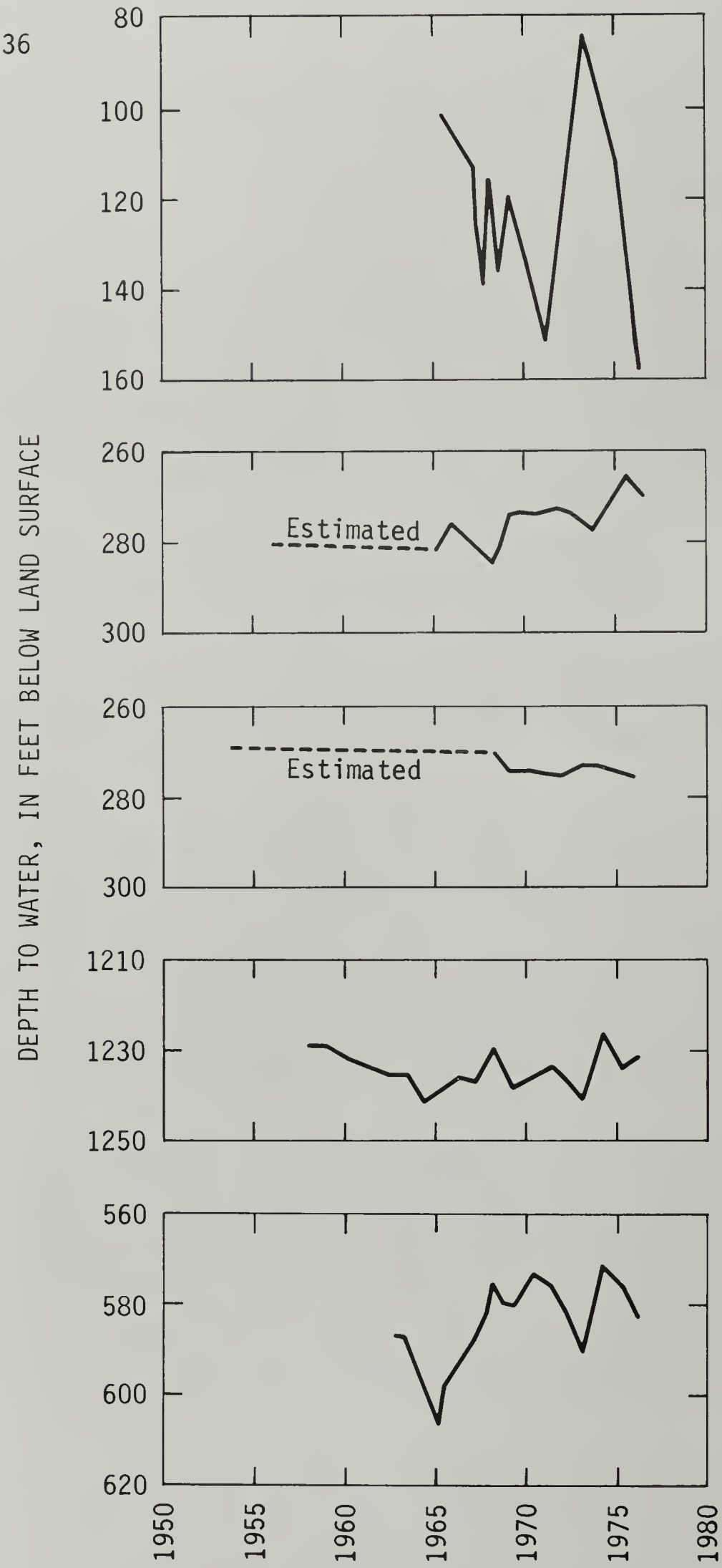
The sedimentary deposits are an important source of ground water in three places—the Inner Basin on the northeastern side of the San Francisco Peaks, Munds Park about 20 mi south of Flagstaff, and the northern part of Aubrey Valley. Minor amounts of ground water are withdrawn at scattered places for livestock and domestic use. Because the water is derived totally from local precipitation or runoff that infiltrates downward into the thin narrow alluvial deposits along major stream channels, these supplies generally are not reliable for sustained use, especially during prolonged dry periods.

The Inner Basin of San Francisco Peaks is a glacially carved valley that is partly filled by glaciofluvial deposits of sand, clay, and boulders. Water from springs and wells in the Inner Basin is used by the city of Flagstaff as a part of the municipal supply. The depth to water in the Inner Basin is from zero to about 200 ft below the land surface and is subject to large seasonal fluctuations. The more permeable deposits yield as much as 500 gal/min to wells from depths of 300 to 500 ft.

At Munds Park, clay, sand, and gravel have filled a valley incised in the volcanic rocks. Several wells that penetrate mainly sand and gravel have produced 100 to 400 gal/min for several days or weeks. Most of the wells however yield about 50 gal/min and some holes that penetrate mainly clay yield little or no water. Water levels in Munds Park are from about 80 ft to as much as 150 ft below the land surface depending on location, time of year, and precipitation conditions. Large fluctuations in water levels can be expected owing to the seasonal demands and the seasonal recharge conditions. The hydrograph of the water level in well (A-18-7)15ccb1 in this area is included in figure 9.

Aubrey Valley contains the largest volume of sedimentary deposits in the study area. Only deposits in the north end of the valley are known to be water bearing. Five wells in that area yield usable quantities of water; the largest reported yield was 30 gal/min near Frazier Wells. Water levels in the five wells ranged from 47 to 422 ft below the land surface. An oil-test hole—(B-25-8)34aa—penetrated 420 ft of clay, sand, and gravel in southern Aubrey Valley but no water was reported at that depth. The sedimentary deposits may be dry in much of the central and southern parts of Aubrey Valley.

Water samples were collected from the five wells that yield water only from sedimentary deposits. The dissolved-solids concentrations in water from four of the wells range from 202 to 388 mg/L and average 298 mg/L (McGavock, 1968, table 4). The principal constituents in the water are calcium and bicarbonate. The water from well (B-27-6)1adc contains 2,220 mg/L dissolved solids, of which about 1,970 mg/L are calcium and sulfate. The alluvial deposits at this site contain some thin




(A-18-7)15ccb1
Well depth: 184 ft
Alluvium

(A-24-5)11cdb
Well depth: 292 ft
Volcanic rocks

(A-18-14)13abd3
City of Winslow
Well depth: 293 ft
Coconino aquifer

(A-21-6)35cba
City of Flagstaff-Woody Mountain
Well depth: 1,600 ft
Coconino aquifer

(A-20-8)18bbb
City of Flagstaff-Lake Mary
Well depth: 1,206 ft
Coconino aquifer

Figure 9.--Water levels in selected wells.

beds of gypsum that are the source of the large concentrations of dissolved solids in the water.

## DEVELOPMENT OF WATER RESOURCES

Water-resources development in southern Coconino County has been slight. The principal use of water in the area is for municipal supplies for Flagstaff and Winslow. Most of the major industries in the area are served by city water systems, and their consumption is included in the estimate of municipal use. Domestic and livestock wells account for a small part of the total use. Agricultural use is minimal; the only cropland and pasture in the study area are a few miles northeast of Flagstaff. Total water use in southern Coconino County from surface-water and ground-water sources is estimated to have been slightly less than 8,000 acre-ft in 1975.

Ground-water development generally is limited by the great depth to water and by the low yields of wells. In some areas, the chemical quality of the water may restrict development for certain uses. The total ground-water production from all aquifers in 1970 was estimated to be 2,600 acre-ft. Estimated ground-water withdrawal in 1975 was 5,200 acre-ft. Most of the ground water withdrawn in southern Coconino County is from the municipal well fields near Flagstaff and Winslow. Water levels in the Winslow well field and Flagstaff well fields near Woody Mountain and Lake Mary have remained relatively stable. Large water-level fluctuations occurred in the nonpumping wells (fig. 9), but this probably is due to the effect of nearby or recent pumping.

Water levels in the aquifers in southern Coconino County have not been seriously affected by historic ground-water withdrawals. The volume of ground water in storage in the study area probably is between 100 and 200 million acre-ft; thus, withdrawal at the estimated 1975 rate should not result in long-term depletion of the system except possibly on a local basis such as in the municipal well fields.

The development of surface-water resources is hindered by the economic considerations of transporting water over long distances and by prior appropriation of water by downstream users. In southern Coconino County more than 4,200 acre-ft of surface water was used for nonrecreational purposes in 1970. The estimated total surface-water use in 1975 was 2,500 acre-ft; the city of Flagstaff used about 2,200 acre-ft, and the city of Williams used less than 300 acre-ft. Annual use of surface-water resources can be extremely variable. Most impoundment structures are constructed on ephemeral streams that flow only in response to rainfall and snowmelt; the available supply is dependent entirely on precipitation.

Leakage from surface-water reservoirs is a major problem in the study area; the land surface commonly is underlain by permeable volcanic rocks or limestone, and many drainages follow zones of broken permeable

rocks. Leakage occurs from Kaibab Lake and Dogtown Reservoir—the major reservoirs for the city of Williams water supply (Thomsen, 1969). Dogtown Reservoir was lined with plastic in 1971 in an attempt to decrease leakage. Data collected by the Geological Survey subsequent to the lining of the reservoir indicates that the lining has been effective. Efforts were underway in 1976 to seal Kaibab Lake. Seepage from Upper Lake Mary, which is the principal source of municipal water for the city of Flagstaff, was 42 percent, or about 3,200 acre-ft/yr, of the total reservoir inflow during 1950-71 (J. W. H. Blee, U.S. Geological Survey, written commun., 1973).

The impounding of surface water for recreational purposes has increased rapidly since 1963. Six reservoirs constructed since 1963 in the headwaters of Clear and Chevelon Creeks have a total controlled storage capacity of more than 27,000 acre-ft. Blue Ridge Reservoir, which is the largest of the six reservoirs, has a usable storage capacity of 15,000 acre-ft. This reservoir is used partly as a holding basin for diversion of water south to the East Verde River. During 1966-73, these diversions averaged 11,400 acre-ft/yr (U.S. Geological Survey, 1961-75).

The water supply for the city of Flagstaff is obtained primarily from surface-water storage in Upper Lake Mary, but a significant part of the supply is obtained from other sources. Springs and infiltration galleries in the Inner Basin of the San Francisco Peaks have been used by the city since 1900, and shallow wells in the Inner Basin have been used since 1968. Deep wells that tap the Coconino aquifer have been used since 1956 to supplement the city's water supply. During 1956-70, the city obtained about 65 percent of its water supply from Upper Lake Mary, about 20 percent from springs in the Inner Basin, and about 15 percent from the Woody Mountain well field. The amount of water obtained from each source has varied greatly from year to year. Since 1970, a well field at Lower Lake Mary has been an added source of water for municipal supply. Total municipal water use by the city of Flagstaff in 1975 was about 5,500 acre-ft.

The city of Winslow is in Navajo County but obtains its entire water supply from five wells in Coconino County about 8 mi southwest of the city. Municipal water consumption in Winslow increased from about 1,270 acre-ft in 1956 to about 1,500 acre-ft in 1975. Ground water in storage in the Coconino aquifer in and near the Winslow well field is sufficient to supply many times the current demand. The chemical quality of the water from four of the municipal wells however has deteriorated gradually, and the city may need to seek other sources of water in the future.

The water supply for the city of Williams is obtained from six reservoirs, which have a total controlled storage capacity of about 2,800 acre-ft. Three reservoirs—Dogtown, Kaibab, and Cataract—contain 85 percent of the storage capacity. The use of water by the city is estimated to be less than 300 acre-ft/yr for 1963-75. Despite this relatively low consumption, the reservoir storage is often insufficient to

meet the demand because of high seepage losses in the reservoirs (Thomsen, 1969).

The water supply in the Sedona area is primarily from wells owned by private water companies or individuals. Most of the wells are west of the study area in Yavapai County. An estimated 1,300 acre-ft of water was pumped from the wells in the Sedona area in 1975; no depletion of the ground-water system was occurring.

## SUMMARY

Southern Coconino County includes about 10,600 $mi^2$ in the Colorado River basin in north-central Arizona. The topography includes rolling high plateaus, deeply incised canyons, and rugged mountains. The areal distribution of precipitation is dependent on altitude and orographic effects; mean annual precipitation in the study area ranges from about 6 to 35 in.

Mean annual surface-water runoff is a small percentage of mean annual precipitation; most precipitation is lost to evapotranspiration or infiltration. Nearly all the streams in the study area are intermittent. Streamflow generally is of acceptable chemical quality for most uses in intermittent and perennial streams during periods of storm and snowmelt runoff; dissolved-solids concentrations commonly are less than 200 mg/L. Dissolved solids in low or base flows in the perennial streams that drain the area range from 200 to 2,600 mg/L.

Ground water occurs chiefly in two aquifers—the Coconino aquifer and a limestone aquifer. The Coconino aquifer is the most highly developed aquifer but does not underlie the entire study area; about 75 percent of the ground water pumped in southern Coconino County comes from this aquifer. Well yields range from about 1 to 1,000 gal/min. Depth to water ranges from about 75 ft near Winslow to about 2,500 ft north of Flagstaff. The chemical quality of the water generally is good; dissolved-solids concentrations commonly are less than 500 mg/L. The limestone aquifer contains water throughout the study area and has the greatest potential well yields but generally is not tapped because the required well depth exceeds 2,500 ft in most places.

In places, ground water also is obtained from the Moenkopi and Chinle Formations, volcanic rocks, and sedimentary deposits. These units yield water of suitable chemical quality for livestock and domestic use in the central part of the area, mainly near Flagstaff, Fort Valley, the Inner Basin of the San Francisco Peaks, and Munds Park. Although the units do not contain water in large areas, they typically contain water at depths of less than 300 ft, and well yields of 10 to 50 gal/min are not uncommon.

The development of ground-water or surface-water resources in southern Coconino County has not been extensive. Ground-water

development generally is hindered by the great depth to water and by the relatively low yields of existing wells. The development of surface-water resources has been hindered by the economic considerations of transporting water over long distances and by prior appropriation of water by downstream users. In 1970 total ground-water production from all sources was about 2,600 acre-ft, and about 4,200 acre-ft of surface water was used for nonrecreational purposes. In 1975 ground-water production was about 5,200 acre-ft, and about 2,500 acre-ft of surface water was used for nonrecreational purposes. Between 100 and 200 million acre-ft of ground water is estimated to be in storage in the study area. Ground-water withdrawals are not resulting in depletion of water in the system or large declines in water levels.

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# HYDROLOGIC DATA

Table 4.--Chemical analyses of water from selected streamflow sites

[Analyses in milligrams per liter, except as indicated. T, trace.
Dissolved solids: Sum of determined constituents]

| Location | Sampling site | Date of collection | Discharge (cubic feet per second) | Temperature (°C) | Silica ($SiO_2$) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$: Calcium, magnesium | Hardness as $CaCO_3$: Noncarbonate | Specific conductance (micromhos at 25°C) | Ph |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LITTLE COLORADO RIVER DRAINAGE BASIN | | | | | | | | | | | | | | | | | | | |
| | Chevelon Creek | | | | | | | | | | | | | | | | | | |
| T. 18 N., R. 17 E., SE¼SW¼ sec. 27 | Near gaging station 09398000; base flow | 5-25-54 | 4.0 | 21 | 9.6 | 69 | 39 | 591 | | 228 | 0 | 139 | 910 | 0.4 | 1,870 | 332 | 146 | 3,440 | --- |
| | | 7-12-55 | 3.4 | 24 | 9.4 | 70 | 43 | 587 | | 249 | 0 | 139 | 905 | .3 | 1,880 | 352 | 148 | 3,380 | 7.2 |
| | | 5-12-71 | 4.2 | 17 | 6.8 | 68 | 45 | 640 | 5.9 | 263 | 0 | 170 | 960 | .2 | 2,030 | 350 | 140 | 3,590 | 7.6 |
| Do. | Near gaging station 09398000; storm runoff | 10- 4-71 | 123 | 13 | 3.7 | 18 | 5.2 | 15 | 1.1 | 75 | 0 | 12 | 22 | .1 | 114 | 66 | 5 | 207 | 7.2 |
| | Clear Creek | | | | | | | | | | | | | | | | | | |
| T. 15 N., R. 13 E., SW¼SE¼ sec. 19 | Near gaging station 09398500; snowmelt runoff | 3-11-66 | 500 | 2 | ---- | 7.2 | 3.9 | 2.1 | | 34 | 0 | 8.0 | 1.0 | .1 | 39 | 34 | 6 | 68 | 7.1 |
| Do. | Near gaging station 09398500; storm runoff | 10-13-71 | 0.38 | 14 | 3.7 | 25 | 12 | 1.6 | .5 | 128 | 0 | 6.5 | 1.7 | .0 | 114 | 110 | 7 | 201 | 8.1 |
| | | 10-17-72 | 4.9 | 16.5 | 4.6 | 20 | 9.8 | 2.8 | 1.0 | 102 | 0 | 7.0 | 4.1 | .1 | 100 | 90 | 7 | 180 | 7.5 |
| Do. | Near gaging station 09398500; snowmelt runoff | 3-20-73 | 258 | ---- | 4.0 | 9.0 | 4.2 | 1.0 | 0.5 | 45 | 0 | 6.7 | 1.5 | .1 | 49 | 40 | 3 | 84 | 7.7 |
| | | 4-25-73 | 1,910 | ---- | 4.7 | 9.2 | 4.1 | 1.0 | 0.6 | 45 | 0 | 5.4 | 1.6 | .0 | 49 | 40 | 3 | 85 | 7.6 |
| | Jacks Canyon | | | | | | | | | | | | | | | | | | |
| T. 18 N., R. 15 E., NW¼NW¼ sec. 31 | Near gaging station 09399400; storm runoff | 8-21-71 | 4.0 | 23 | 9.1 | 25 | 2.2 | 2.2 | 4.7 | 97 | 0 | 3.3 | 1.4 | .4 | 98 | 71 | 0 | 157 | 7.4 |
| | | 12-28-71 | 127 | 3.5 | 14 | 13 | 2.5 | 2.6 | 2.4 | 46 | 0 | 5.8 | 3.7 | .2 | 67 | 43 | 5 | 85 | 6.8 |
| | | 12-30-71 | 23 | 2.0 | 14 | 11 | 2.6 | 1.0 | 2.7 | 46 | 0 | 5.5 | 2.8 | .2 | 63 | 38 | 0 | 86 | 6.9 |
| | | 12-31-71 | 10 | .5 | 15 | 13 | 3.0 | 2.0 | 2.7 | 47 | 0 | 5.9 | 1.9 | .1 | 68 | 45 | 6 | 89 | 7.0 |
| | Schultz Canyon | | | | | | | | | | | | | | | | | | |
| T. 21 N., R. 7 E., SE¼SW¼ sec. 4 | At partial-record station 09400595; storm runoff | 3-13-73 | 15 | 7.0 | 26 | 11 | 4.2 | 4.3 | 2.7 | 52 | 0 | 8.2 | 1.6 | .2 | 107 | 45 | 2 | 109 | 7.2 |
| | Rio de Flag | | | | | | | | | | | | | | | | | | |
| T. 21 N., R. 7 E., NW¼NE¼ sec. 9 | At partial-record station 09400600; storm runoff | 3-13-73 | 94 | 6.5 | 23 | 10 | 4.3 | 3.8 | 2.6 | 53 | 0 | 6.1 | 2.0 | .2 | 104 | 43 | 0 | 108 | 7.2 |

Table 4.--Chemical analyses of water from selected streamflow sites—Continued

| Location | Sampling site | Date of collection | Discharge (cubic feet per second) | Temperature (°C) | Silica ($SiO_2$) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO^3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$: Calcium, magnesium | Hardness as $CaCO_3$: Noncarbonate | Specific conductance (micromhos at 25°C) | Ph |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LITTLE COLORADO RIVER DRAINAGE BASIN—CONTINUED | | | | | | | | | | | | | | | | | | | |
| | Switzer Canyon | | | | | | | | | | | | | | | | | | |
| T. 21 N., R. 7 E., SW¼SE¼ sec. 10 | At partial-record station 09400680; storm runoff | 3-13-73 | 75 | 4.5 | 11 | 4.9 | 1.9 | 1.6 | 1.4 | 29 | 0 | 2.3 | 0.5 | 0.1 | 51 | 20 | 0 | 50 | 7.0 |
| | Little Colorado River | | | | | | | | | | | | | | | | | | |
| T. 29 N., R. 8 E., NW¼ sec. 5 | At gaging station 09402000; storm runoff | 10-28-69 | 75 | 11.0 | ---- | 34 | 4.6 | 170 | 4.3 | 232 | 0 | 202 | 72 | --- | 628 | 104 | 0 | 990 | 7.8 |
| | | 3-26-70 | 56 | 4.5 | ---- | 17 | 2.8 | 96 | 2.6 | 155 | 0 | 37 | 78 | --- | 355 | 54 | 0 | 570 | 8.2 |
| | | 1-27-71 | 0.60 | 0.5 | 8.0 | 91 | 24 | 160 | 5.2 | 205 | 0 | 420 | 38 | 0.6 | 916 | 330 | 162 | 1,270 | 8.0 |
| | | 10-28-71 | 2,300 | 9.0 | 7.7 | 11 | 2.4 | 89 | 1.9 | 118 | 0 | 63 | 65 | 0.5 | 326 | 37 | 0 | 497 | 7.8 |
| | | 1-27-72 | 31 | 1.0 | 9.8 | 76 | 18 | 200 | 3.9 | 209 | 0 | 180 | 250 | 0.4 | 868 | 260 | 92 | 1,500 | --- |
| T. 33 N., R. 6 E., NW¼SW¼ sec. 33 | 3.1 miles above mouth of river; base flow | 5-17-66 | ----- | 22 | 17 | 112 | 77 | 761 | | 464 | 0 | 170 | 1,200 | 0.2 | 2,560 | 595 | 215 | 4,540 | 7.3 |
| | | 7-12-66 | 230 | 24 | 15 | 120 | 79 | 765 | | 494 | 0 | 170 | 1,210 | 0.2 | 2,600 | 625 | 220 | 4,580 | 7.8 |
| | | 11- 2-66 | 217 | -- | 18 | 96 | 76 | 795 | | 476 | 0 | 175 | 1,210 | 0.3 | 2,600 | 550 | 160 | 4,580 | 7.7 |
| | | 3-15-67 | ----- | 18 | 18 | 120 | 69 | 777 | | 488 | 0 | 175 | 1,200 | 0.3 | 2,600 | 585 | 185 | 4,610 | 7.4 |
| HAVASU CREEK DRAINAGE BASIN | | | | | | | | | | | | | | | | | | | |
| | West Cataract Creek | | | | | | | | | | | | | | | | | | |
| T. 22 N., R. 2 E., NW¼ sec. 31 | At partial-record station 09403930; storm runoff | 3-26-73 | 3.3 | 0.5 | 19 | 11 | 4.0 | 2.9 | 2.2 | 56 | 0 | 5.4 | 2.2 | 0.1 | 106 | 44 | 0 | 103 | 7.3 |
| | Cataract Creek | | | | | | | | | | | | | | | | | | |
| T. 27 N., R. 2 W., NE¼SE¼ sec. 13 | At partial-record station 09404100; storm runoff | 4- 6-73 | 17 | 13.0 | 15 | 16 | 3.3 | 3.6 | 2.5 | 75 | 0 | 4.6 | 1.7 | 0.0 | 109 | 54 | 0 | 109 | 7.3 |
| | Havasu Creek | | | | | | | | | | | | | | | | | | |
| T. 33 N., R. 4 W., sec. 10 | 2 miles below Supai Village; base flow | 8-23-68 | 53.7 | ---- | 23 | 78 | 44 | 41 | | 436 | 0 | 36 | 48 | 0.3 | 485 | 374 | 16 | 836 | 7.8 |
| T. 34 N., R. 4 W., sec. 32 | 4 miles below Supai Village; base flow | 6-16-51 | ----- | 21 | --- | 52 | 47 | 28 | | 338 | trace | 38 | 48 | 0 | 380 | 323 | 46 | 704 | --- |
| T. 34 N., R. 4 W., sec. 31 | 500 feet above mouth; base flow | 6-16-51 | 63.3 | 21 | --- | -- | --- | --- | | 304 | trace | ---- | 48 | --- | ----- | --- | --- | 661 | --- |

Table 4.--Chemical analyses of water from selected streamflow sites—Continued

| Location | Sampling site | Date of collection | Discharge (cubic feet per second) | Temperature (°C) | Silica ($SiO_2$) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$: Calcium, magnesium | Hardness as $CaCO_3$: Noncarbonate | Specific conductance (micromhos at 25°C) | Ph |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VEROE RIVER DRAINAGE BASIN | | | | | | | | | | | | | | | | | | | |
| | Oak Creek | | | | | | | | | | | | | | | | | | |
| T. 16 N., R. 4 E., NE¼NW¼SE¼ sec. 23 | At gaging station 09504500; base flow | 9-14-67 | 24.7 | 22 | 18 | 47 | 20 | 1.6 | | 224 | 0 | 4.0 | 10 | 0 | 211 | 198 | 64 | 396 | 7.5 |
| Do. | At gaging station 09504500; snowmelt runoff | 4-15-68 | 63 | 16 | 15 | 24 | 11 | 4.1 | | 126 | 0 | 5.0 | 3.5 | 0.1 | 125 | 104 | 1 | 210 | 7.1 |
| Do. | At gaging station 09504500; base runoff | 10-12-71 | 25 | 22 | 15 | 42 | 20 | 8.6 | 1.0 | 242 | 0 | 4.8 | 8.9 | 0 | 220 | 190 | 0 | 380 | 8.1 |
| Do. | At gaging station 09504500; snowmelt runoff | 4-10-73 | 764 | 10 | 12 | 14 | 5.2 | 2.2 | 0.8 | 64 | 0 | 3.6 | 1.3 | 0.1 | 71 | 56 | 4 | 112 | 7.5 |
| | Wet Beaver Creek | | | | | | | | | | | | | | | | | | |
| T. 15 N., R. 6 E., NW¼SW¼ sec. 24 | At gaging station 09505200; base runoff | 9-15-67 | 6.2 | 22 | 21 | 29 | 14 | 5.0 | | 164 | 0 | 2.0 | 4.5 | 0 | 156 | 132 | 0 | 267 | 7.3 |
| T. 15 N., R. 6 E., NW¼SW¼ sec. 24 | Near gaging station 09505200; base runoff | 10-14-71 | 6.9 | 17.5 | 20 | 24 | 14 | 6.3 | 1.1 | 164 | 0 | 3.8 | 2.8 | 0.1 | 153 | 120 | 0 | 249 | 8.1 |
| Do. | Near gage, snowmelt runoff | 4- 3-73 | 110 | 6 | 14 | 11 | 4.7 | 2.2 | 1.3 | 56 | 0 | 7.8 | 2.1 | 0.0 | 71 | 47 | 1 | 99 | 7.7 |
| T. 15 N., R. 6 E., NE¼NE¼ sec. 28 | 2.5 miles below gaging station 09505200; snowmelt runoff | 4-15-68 | 32 | 14 | 17 | 11 | 6.4 | 3.2 | | 68 | 0 | 4.0 | 1.5 | 0.1 | 76 | 54 | 0 | 118 | 6.7 |
| | Red Tank Draw | | | | | | | | | | | | | | | | | | |
| T. 15 N., R. 6 E., SE¼NE¼ sec. 16 | At gaging station 09505250; snowmelt runoff | 4-15-68 | 0.3 | 17 | 25 | 38 | 17 | 6.9 | | 200 | 0 | 5.0 | 7.0 | 0.1 | 197 | 164 | 0 | 330 | 7.4 |
| | | 4- 3-73 | 52 | 8 | 14 | 12 | 4.4 | 2.2 | 1.5 | 57 | 0 | 7.0 | 2.4 | 0.0 | 72 | 48 | 1 | 105 | 7.8 |

Table 4.--Chemical analyses of water from selected streamflow sites—Continued

| Location | Sampling site | Date of collection | Discharge (cubic feet per second) | Temperature (°C) | Silica ($SiO_2$) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$: Calcium, magnesium | Hardness as $CaCO_3$: Noncarbonate | Specific conductance (micromhos at 25°C) | Ph |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VEROE RIVER DRAINAGE BASIN—CONTINUED | | | | | | | | | | | | | | | | | | | |
| | Rattlesnake Canyon | | | | | | | | | | | | | | | | | | |
| T. 16 N., R. 7 E., SE¼SE¼ sec. 18 | 2 miles above gaging station 09505300; snowmelt runoff | 4-15-68 | 6.9 | 14 | 17 | 6.0 | 3.6 | | 4.4 | 30 | 0 | 11 | 2.5 | 0.1 | 60 | 30 | 6 | 79 | 6.4 |
| T. 16 N., R. 6 E., NW¼SW¼ sec. 24 | Near gage 09505300; snowmelt runoff | 4-16-73 | 78 | 6 | 13 | 5.8 | 2.8 | 1.8 | 0.5 | 29 | 0 | 3.6 | 0.1 | 0.0 | 43 | 26 | 2 | 58 | 7.6 |
| | Dry Beaver Creek | | | | | | | | | | | | | | | | | | |
| T. 15 N., R. 5 E., NE¼NW¼ sec. 1 | At gaging station 09505350; snowmelt runoff | 4-15-68 | 58 | 15 | 16 | 7.6 | 3.6 | | 2.1 | 40 | 0 | 4.0 | 1.0 | 0.1 | 54 | 34 | 1 | 77 | 7.0 |
| | | 3- 2-73 | 139 | 7.5 | 13 | 7.1 | 3.1 | 1.9 | 0.7 | 39 | 0 | 6.1 | 1.8 | 0.1 | 53 | 31 | 0 | 71 | 7.8 |
| | | 4-26-73 | 548 | ---- | 11 | 4.8 | 2.2 | 1.3 | 0.5 | 26 | 0 | 3.7 | 1.5 | 0.0 | 38 | 21 | 0 | 50 | 7.7 |
| | West Clear Creek | | | | | | | | | | | | | | | | | | |
| T. 13 N., R. 6 E., NW¼NW¼NW¼ sec. 11 | At gaging station 09505800; base flow | 9-15-67 | 14.3 | 22 | 18 | 42 | 20 | | 8.7 | 236 | 0 | 5.0 | 4.5 | 0 | 214 | 186 | 0 | 366 | 7.5 |
| | | 10-12-71 | 15 | ---- | 17 | 39 | 23 | 5.7 | 1.1 | 251 | 0 | 1.5 | 3.3 | 0.1 | 214 | 190 | 0 | 370 | --- |
| Do. | At gaging station 09505800; storm runoff | 10-7-72 | 1,040 | 17 | 14 | 14 | 5.6 | 1.5 | 1.9 | 63 | 0 | 9.3 | 1.9 | 0.1 | 80 | 58 | 6 | 127 | 6.8 |
| Do. | At gaging station 09505800; snowmelt runoff | 4-11-73 | 1,300 | 5.5 | 10 | 9.3 | 3.8 | 1.5 | 0.8 | 45 | 0 | 4.0 | 0.9 | 0.1 | 53 | 39 | 2 | 81 | 7.3 |
| T. 13 N., R. 5 E., SW¼NE¼ sec. 13 | 5 miles below gaging station 09505800; snowmelt runoff | 4-15-68 | 135 | 15 | 18 | 17 | 8.1 | | 3.4 | 96 | 0 | 3.0 | 1.5 | 0.1 | 98 | 76 | 0 | 161 | 7.0 |

Table 5.--Chemical analyses of water from selected springs

[Analyses in milligrams per liter, except as indicated. Discharge: R, reported; E, estimated. Dissolved solids: Sum of determined constituents. Remarks: Stratigraphic names indicate water-bearing unit]

| Location | Date of collection | Discharge (gallons per minute) | Temperature (°C) | Silica ($SiO_2$) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$: Calcium, magnesium | Hardness as $CaCO_3$: Noncarbonate | Specific conductance (micromhos at 25°C) | Ph | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LITTLE COLORADO RIVER DRAINAGE BASIN | | | | | | | | | | | | | | | | | | | |
| (A-17-17)22ccc | 7- 8-66 | ------- | 19 | 14 | 114 | 38 | 152 | | 166 | 0 | 300 | 230 | 0.1 | 930 | 442 | 306 | 1,530 | 7.4 | Seep zone in Chevelon Creek; Coconino Sandstone |
| (A-18-16)30dd | 7- 7-66 | ------- | 17 | 13 | 50 | 24 | 178 | | 222 | 0 | 32 | 280 | .1 | 686 | 224 | 42 | 1,280 | 7.7 | Seep zone in Clear Creek; Coconino Sandstone. |
| (A-18-16)31bbb | 7- 7-66 | ------- | 20 | 14 | 46 | 27 | 576 | | 160 | 0 | 50 | 920 | .2 | 1,710 | 228 | 97 | 3,200 | 7.8 | Do. |
| (A-32-6)3bd(a) | 1-29-66 | ------- | 23 | ---- | 646 | 291 | 8,184 | | 2,470 | 0 | 2,950 | 11,000 | 1.5 | 24,380 | 2,810 | 787 | 33,800 | 6.5 | Si-Pa-Po Spring; Little Colorado River mile 4.5; Tapeats Sandstone. |
| (A-32-6)36ada | 7-12-66 | 15,750 | ---- | 17 | 214 | 73 | 623 | | 936 | 0 | 135 | 910 | 0 | 2,430 | 835 | 68 | 4,170 | 7.0 | First spring below Blue Spring; Little Colorado River mile 12.9; Muav Limestone. |
| (A-32-6)36add | 6-14-50 | 42,750 | ---- | 19 | 264 | 79 | 513 | 23 | 964 | 0 | 147 | 815 | .2 | 2,340 | 984 | 194 | 3,940 | 6.5 | Blue Spring; Little Colorado River mile 13.1; Muav Limestone. |
| | 5-17-66 | 42,250 | 21 | 17 | 252 | 76 | 535 | | 951 | 0 | 140 | 835 | .3 | 2,320 | 940 | 161 | 3,960 | 6.8 | Do. |
| (A-32-7)31bbc | 7-12-66 | 11,250 | ---- | 16 | 238 | 67 | 785 | | 840 | 0 | 175 | 1,210 | .2 | 2,900 | 870 | 182 | 5,000 | 6.9 | Second spring below Blue Spring; Little Colorado River mile 12.8; Muav Limestone. |
| (A-33-6)33b | 5-17-66 | ------- | 22 | 17 | 112 | 77 | 761 | | 464 | 0 | 170 | 1,200 | .2 | 2,560 | 595 | 215 | 4,540 | 7.3 | Composite of all spring flow from Blue Spring to Little Colorado River mile 3.1; Muav Limestone and Tapeats(?) Sandstone. |
| | 7-12-66 | ------- | 24 | 15 | 120 | 79 | 765 | | 494 | 0 | 170 | 1,210 | .2 | 2,600 | 625 | --- | 4,580 | 7.8 | Do. |
| COLORADO RIVER DRAINAGE BASIN | | | | | | | | | | | | | | | | | | | |
| (A-31-2)7 | 10-16-57 | 210 | ---- | 9.2 | 52 | 31 | 27 | | 267 | 0 | 33 | 44 | .2 | 328 | 257 | 38 | 584 | --- | Hermit Springs; Muav Limestone. |
| (A-31-2)13abb | 4-9-58 | 300R | 12 | 12 | 54 | 35 | 11 | | 308 | 0 | 28 | 14 | .2 | 305 | 278 | 26 | 543 | --- | Indian Gardens Spring; Muav Limestone. |
| (B-27-9)20acb | 5-15-58 | >300 | 22 | 26 | 50 | 21 | 18 | | 228 | 0 | 15 | 24 | .5 | 282 | 212 | --- | 460 | --- | Diamond Spring; Muav Limestone. |
| (B-33-8)36d | 6-20-60 | 2,700E | 26 | ---- | 54 | 80 | 58 | | 532 | 0 | 38 | 80 | --- | 572 | 462 | 26 | 1,100 | --- | Warm Spring; Muav Limestone. |

Table 5.--Chemical analyses of water from selected springs—Continued

| Location | Date of collection | Discharge (gallons per minute) | Temperature (°C) | Silica ($SiO_2$) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$: Calcium, magnesium | Hardness as $CaCO_3$: Noncarbonate | Specific conductance (micromhos at 25°C) | Ph | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HAVASU CREEK DRAINAGE BASIN | | | | | | | | | | | | | | | | | | | |
| (8-33-4)26b | 10-20-50 | 27,900 | 21 | --- | 133 | 48 | 27 | | 588 | 0 | 36 | 48 | 0.2 | 584 | 530 | 48 | 1,030 | --- | Havasu Springs; Pennsylvanian Limestone. |
| | 8- 7-65 | 26,700 | ---- | --- | 74 | 45 | 36 | | 416 | 0 | 36 | 48 | .2 | ------ | 368 | 27 | 820 | 7.7 | Do. |
| | 12-28-66 | 29,900 | 21 | 18 | 118 | 45 | 33 | | 542 | 0 | 38 | 46 | .3 | 565 | 478 | 34 | 973 | 7.7 | Do. |
| | 11-12-67 | 27,700 | 21 | 18 | 125 | 32 | 40 | | 523 | 0 | 40 | 45 | .2 | 558 | 446 | 18 | 961 | 7.4 | Do. |
| | 6-29-68 | ------- | 20 | 20 | 134 | 43 | 42 | | 602 | 0 | 38 | 50 | .3 | 623 | 512 | 18 | 1,050 | 7.2 | Do. |
| VERDE RIVER DRAINAGE BASIN | | | | | | | | | | | | | | | | | | | |
| (A-12-7)14da | 2-16-52 | 18,600 | 21 | 14 | 104 | 40 | | 6.9 | 485 | --- | 27 | 9 | .1 | 440 | 424 | --- | 753 | --- | Fossil Springs; Naco Formation. |
| (A-14-8)32aa | 5-28-59 | 1,000E | 16 | 20 | 51 | 22 | | 5.5 | 268 | --- | 1.6 | 6.0 | 0 | 239 | 218 | --- | 401 | 8.0 | Buckhorn Spring; Coconino Sandstone. |
| (A-14-9)31dd | 5-27-59 | 100E | 11 | 21 | 55 | 22 | | 5.1 | 284 | --- | .6 | 4.0 | .1 | 248 | 228 | --- | 418 | 7.8 | Bear Spring; Coconino Sandstone. |
| (A-15-7)14acc | 10-19-59 | 1,350E | 16 | 23 | 29 | 10 | | 4.8 | 147 | --- | .2 | 2.5 | .2 | 143 | 115 | --- | 236 | 7.4 | Wet Beaver Creek Springs; Coconino Sandstone. |
| (A-16-4)23bbd | 7-14-59 | ------- | 20 | 20 | 56 | 22 | | 13 | 270 | --- | 4.7 | 20 | .2 | 270 | 228 | --- | 463 | 7.6 | Bubbling Pond; Supai(?) Formation. |
| | 5-20-68 | 3,900 | 19.5 | 21 | 54 | 25 | 16 | 1.0 | 279 | 0 | 5.0 | 22 | .2 | 281 | 238 | 10 | 498 | 7.3 | Do. |
| (A-16-4)23dda | 8- 4-49 | ------- | 20 | 18 | 42 | 19 | | 8.7 | 227 | --- | 3.7 | 8.0 | 0 | 212 | 183 | --- | 364 | --- | Page Springs; Supai(?) Formation. |
| | 5-20-68 | 2,075 | 20 | 19 | 42 | 18 | | 10 | 229 | 0 | 3.0 | 8.5 | .2 | 214 | 180 | 0 | 374 | 7.1 | Do. |
| (A-17-3)5db | 10-10-51 | 2,700 | 19 | 15 | 72 | 27 | | 5.8 | 341 | --- | 7.6 | 10 | .2 | 307 | 290 | --- | 543 | --- | Summers Spring; Redwall Limestone. |
| (A-19-6)15ddd | 8-10-46 | 290 | 11 | --- | 32 | 13 | | 9.2 | 163 | 6.9 | 2.9 | 3.0 | .4 | 135 | 134 | --- | 270 | --- | Sterling Spring; Coconino Sandstone. |

Table 6.--Chemical analyses of water from selected wells

[Analyses by U.S. Geological Survey, except as indicated. Analyses in milligrams per liter, except as indicated. Dissolved solids: Sum of determined constituents. Remarks: CT, sample obtained from closed storage tank at well; ATL, analysis by Arizona Testing Laboratories; stratigraphic names indicate water-bearing unit]

| Well location | Date of collection | Temperature (°C) | Silica ($SiO_2$) | Iron (Fe) in solution at time of analysis | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_3$) | Dissolved solids | Hardness as $CaCO_3$: Calcium, magnesium | Hardness as $CaCO_3$: Noncarbonate | Specific conductance (micromhos at 25°C) | pH | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (A-18-14)13abd2 | 8-25-53 | -- | 19 | ---- | 60 | 34 | 79 | | 264 | 0 | 110 | 92 | 0 | --- | 531 | 289 | --- | ------ | 7.5 | Winslow 1; ATL; Coconino Sandstone. |
| | 11-17-59 | -- | 11 | ---- | 90 | 39 | 254 | | 256 | 0 | 110 | 432 | 0.4 | --- | 1,060 | 386 | --- | ------ | 7.2 | Do. |
| | 10-25-65 | -- | 7 | ---- | 98 | -- | 389 | | 251 | 0 | 325 | 390 | .4 | --- | 1,340 | 360 | --- | ------ | 7.5 | Do. |
| | 3- 3-66 | -- | ---- | ---- | 82 | 44 | 249 | | 258 | 0 | 130 | 410 | .2 | --- | 1,040 | 384 | --- | 1,850 | 7.5 | Coconino Sandstone. |
| 13baa | 1- 8-55 | -- | 6.8 | ---- | 70 | 37 | 93 | | 276 | 0 | 100 | 246 | 0 | --- | 692 | 326 | --- | ------ | 7.7 | Winslow 2; ATL; Coconino Sandstone. |
| | 11-17-59 | -- | 10 | ---- | 70 | 43 | 133 | | 276 | 0 | 90 | 226 | .5 | --- | 710 | 354 | --- | ------ | 7.3 | Do. |
| | 11-17-64 | 17 | 12 | ---- | 38 | 44 | 178 | | 150 | 8 | 123 | 280 | .2 | --- | 758 | 274 | 138 | 1,370 | 8.6 | Coconino Sandstone. |
| | 10-25-65 | -- | 8 | ---- | 92 | 10 | 294 | | 288 | 0 | 230 | 308 | .3 | --- | 1,090 | 370 | --- | ------ | 7.5 | ATL; Coconino Sandstone. |
| 13bad | 1-10-63 | -- | 10 | ---- | 113 | 12 | 64 | | 249 | 0 | 111 | 106 | .4 | --- | 541 | 330 | --- | ------ | 7.6 | Winslow 5; ATL; Coconino Sandstone and Supai Formation. |
| | 10-16-64 | -- | 10 | ---- | 116 | 8 | 152 | | 300 | 0 | 100 | 214 | .3 | --- | 750 | 322 | --- | ------ | 7.6 | Do. |
| | 10-26-65 | -- | ---- | ---- | 76 | 12 | 288 | | 300 | 0 | 250 | 254 | .2 | --- | 1,040 | 340 | --- | ------ | 7.6 | Do. |
| 13cab | 1-8-55 | -- | 8.2 | ---- | 64 | 32 | 14 | | 251 | 0 | 90 | 16 | 1.2 | --- | 351 | 290 | --- | ------ | 7.9 | Winslow 3; ATL; Coconino Sandstone. |
| | 3-3-66 | -- | ---- | ---- | 66 | 36 | 7.1 | | 257 | 0 | 99 | 11 | .2 | --- | 348 | 314 | --- | 587 | 7.6 | Coconino Sandstone. |
| 13dbb | 4-27-55 | -- | 5.2 | ---- | 65 | 35 | 13 | | 246 | 0 | 110 | 12 | 0 | --- | 366 | 306 | --- | ------ | 7.8 | Winslow 4; ATL; Coconino Sandstone and Supai Formation. |
| | 10-25-65 | -- | ---- | ---- | 74 | 9 | 133 | | 288 | 0 | 215 | 36 | .2 | --- | 620 | 320 | --- | ------ | 7.6 | Do. |
| 36daa | 8- 2-50 | -- | ---- | ---- | -- | -- | ----- | | 259 | 0 | --- | 90 | --- | --- | --- | 308 | --- | 887 | --- | Coconino Sandstone. |
| | 5- 3-66 | 17 | ---- | ---- | 72 | 37 | 55 | | 255 | 0 | 122 | 82 | .1 | --- | 494 | 332 | 123 | 844 | 7.7 | Do. |
| (A-19-13)7bbb | 11-20-33 | -- | ---- | ---- | 94 | 44 | 16 | | 224 | 0 | 226 | 21 | 0 | 1.0 | 512 | 415 | --- | ------ | --- | Do. |
| | 6- -66 | -- | 14 | 0.01 | 91 | 40 | 18 | | 230 | 0 | 205 | 21 | .2 | --- | 502 | 392 | 204 | 778 | 7.5 | Do. |
| (A-19-14)21a | 11-11-33 | -- | ---- | ---- | 79 | 47 | 239 | | 264 | 0 | 135 | 392 | 0 | .4 | 1,020 | 390 | --- | ------ | --- | Do. |
| | 5-11-66 | 16 | 15 | 0 | 73 | 47 | 260 | | 265 | 0 | 135 | 413 | .1 | --- | 1,070 | 374 | 157 | 1,890 | 7.3 | Do. |
| (A-20-6)2bca | 3-29-68 | 23 | 22 | 0.07 | 21 | 11 | 7.4 | | 132 | 0 | 2.0 | 3.0 | .1 | --- | 132 | 98 | 0 | 220 | 7.1 | City of Flagstaff, Woody Mountain 6; Coconino Sandstone and Supai Formation. |
| (A-20-12½)14dda | 11-20-33 | -- | ---- | ---- | 108 | 50 | 25 | | 226 | 0 | 295 | 26 | 0 | 1.2 | 616 | 475 | --- | ------ | --- | Coconino Sandstone |
| | 3-12-53 | -- | 7.6 | ---- | 98 | 47 | 20 | | 207 | 0 | 269 | 22 | .3 | .2 | 566 | 438 | 268 | 859 | --- | Do. |
| 24cbb | 7- 8-46 | -- | ---- | ---- | 105 | 45 | 31 | | 225 | 0 | 280 | 26 | 0 | 1.7 | 600 | 447 | 262 | 891 | --- | CT; Coconino Sandstone. |
| | 5- -66 | -- | 13 | 0.01 | 106 | 44 | 30 | | 224 | 0 | 281 | 24 | .2 | --- | 608 | 446 | 263 | 890 | 7.5 | Do. |
| (A-20-13)35da | 11-20-33 | -- | ---- | ---- | 78 | 43 | 33 | | 232 | 0 | 157 | 63 | 0 | .2 | 488 | 371 | --- | ----- | --- | Coconino Sandstone. |
| | 3-12-53 | -- | 12 | ---- | 78 | 40 | 33 | | 233 | 0 | 143 | 64 | .2 | .4 | 486 | 359 | 168 | 808 | --- | Do. |
| | 5-12-66 | -- | 13 | .07 | 76 | 40 | 36 | | 236 | 0 | 147 | 62 | .1 | --- | 490 | 356 | 163 | 799 | 7.6 | Do. |
| (A-23-10)1bb | 10-19-54 | -- | 8.5 | ---- | 57 | 47 | 159 | | 205 | 0 | 213 | 205 | .8 | .3 | 792 | 336 | 168 | 1,330 | --- | Coconino(?) Sandstone. |
| | 7-19-65 | -- | ---- | ---- | 73 | 57 | 147 | | 200 | 0 | 230 | 236 | .5 | --- | ----- | 416 | 252 | 1,440 | 8.0 | Do. |
| 13dc | 10-19-54 | -- | 12 | ---- | 93 | 59 | 370 | | 172 | 0 | 270 | 605 | .6 | 3.2 | 1,500 | 474 | 334 | 2,590 | --- | Do. |
| | 7-18-65 | -- | ---- | ---- | 89 | 65 | 359 | | --- | 0 | 255 | 615 | .6 | --- | ----- | 490 | 353 | 2,610 | 7.6 | Do. |
| (A-25-2)27aba | 1-10-70 | -- | 9.4 | 0 | 9.6 | 351 | 4,330 | | 1,110 | 132 | 270 | 6,720 | .5 | --- | 12,400 | 1,470 | 339 | 20,200 | 8.4 | Tapeats Sandstone. |
| (A-27-9)6dc1 | 5-15-56 | 17 | 11 | ---- | 101 | 58 | 27 | | 536 | 0 | 32 | 53 | .4 | .6 | 547 | 490 | 51 | 980 | 7.5 | CT; Supai Formation. |
| | 5-12-66 | -- | ---- | 0 | 95 | 62 | 39 | | 527 | 0 | 43 | 70 | .4 | --- | ----- | 492 | 60 | 1,000 | 7.6 | Supai Formation. |

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ARIZONA DEPARTMENT OF
WATER RESOURCES BULLETIN 5

# WATER RESOURCES OF THE NORTHERN PART OF THE AGUA FRIA AREA YAVAPAI COUNTY, ARIZONA

BY RICHARD P. WILSON

PREPARED BY THE U.S. GEOLOGICAL SURVEY
DEPARTMENT OF THE INTERIOR

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5. Water resources of the northern part of the Agua Fria area, Yavapai County, Arizona, by Richard P. Wilson: 109 p., 3 pls., 5 figs., 1988.

Cover: HYDRAULIC MINING
ALONG LYNX CREEK ABOUT 1890

Cover photograph courtesy of
Arizona Historical Society Museum,
Tucson, Arizona

ARIZONA DEPARTMENT OF WATER RESOURCES
BULLETIN 5

# WATER RESOURCES OF THE NORTHERN PART OF THE AGUA FRIA AREA, YAVAPAI COUNTY, ARIZONA

By Richard P. Wilson

Prepared by the U.S. GEOLOGICAL SURVEY
DEPARTMENT OF THE INTERIOR

Tucson, Arizona
1988

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# CONVERSION FACTORS

For readers who prefer to use metric units (International System), the conversion factors for the inch-pound units used in this report are listed below:

| Multiply inch-pound unit | By | To obtain metric unit |
|---|---|---|
| inch (in.) | 25.4 | millimeter (mm) |
| foot (ft) | 0.3048 | meter (m) |
| vara (vr) | 1.181 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |
| acre | 0.404 | square hectometer ($hm^2$) |
| acre-foot (acre-ft) | 0.001233 | cubic hectometer ($hm^3$) |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |
| acre-foot per acre (acre-ft/acre) | 0.3048 | cubic hectometer per square hectometer ($hm^3/hm^2$) |
| gallon per minute (gal/min) | 0.06309 | liter per second (L/s) |
| gallon per minute per foot [(gal/min)/ft] | 0.207 | liter per second per meter [(L/s)/m] |
| micromho per centimeter (μmho/cm) at 25°C | 1 | microsiemen per centimeter (μS/cm) at 25°C |

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea level of 1929."

# WATER RESOURCES OF THE NORTHERN PART OF THE AGUA FRIA AREA, YAVAPAI COUNTY, ARIZONA

By

Richard P. Wilson

---

## ABSTRACT

At least 1,400,000 acre-feet of ground water is in storage in the major aquifers in the 700-square-mile northern part of the Agua Fria area. The study area is divided into three subareas—Lonesome Valley, Mayer, and Black Hills—that are separated by nearly impermeable basement rocks that prevent significant ground-water flow between them. Ground-water development in either Lonesome Valley or Mayer will affect ground-water conditions in the Black Hills only by decreasing potential recharge from base flow in the Agua Fria River by less than 500 acre-feet per year or in Big Bug Creek by a few acre-feet per year. Development in the Black Hills subarea will not affect the other two subareas. The Lonesome Valley subarea contains about 800,000 acre-feet of water in storage and is the most favorable for development of new water supplies. A few thousand acre-feet of water are in storage in the Mayer subarea. An estimate of water in storage in the Black Hills subarea is 600,000 acre-feet. The most favorable area for development of new water supplies in the Black Hills subarea is along the west side where basin fill crops out. An estimated ground-water budget for the 1981 water year included a discharge of about 9,700 acre-feet. Estimated recharge was 14,700 acre-feet, which is the sum of the discharge and the change in storage of about 5,000 acre-feet and is greater than in an average year. The chemical quality of the ground water and base flow of Agua Fria River and its tributaries generally is acceptable for public supply, domestic use, livestock, and irrigation of crops. The general chemical character of ground water in the major aquifers is calcium bicarbonate. Total dissolved solids ranged from about 132 to 748 milligrams per liter. Fluoride concentrations ranged from 0.1 to 1.0 milligrams per liter.

## INTRODUCTION

The northern part of the Agua Fria area includes about 700 $mi^2$ in Yavapai County, north-central Arizona (fig. 1). A rapid population growth and subsequent urbanization and development are increasing the demands on the water supply. Ground water is the source for all public water supplies and most irrigation and private supplies. Increased water-use demands in the near future will be met by increased ground-water withdrawals. Alternate sources are not available at this time. Direct runoff and perennial streamflow in the Agua Fria River and tributaries are reserved for local and downstream users who have existing

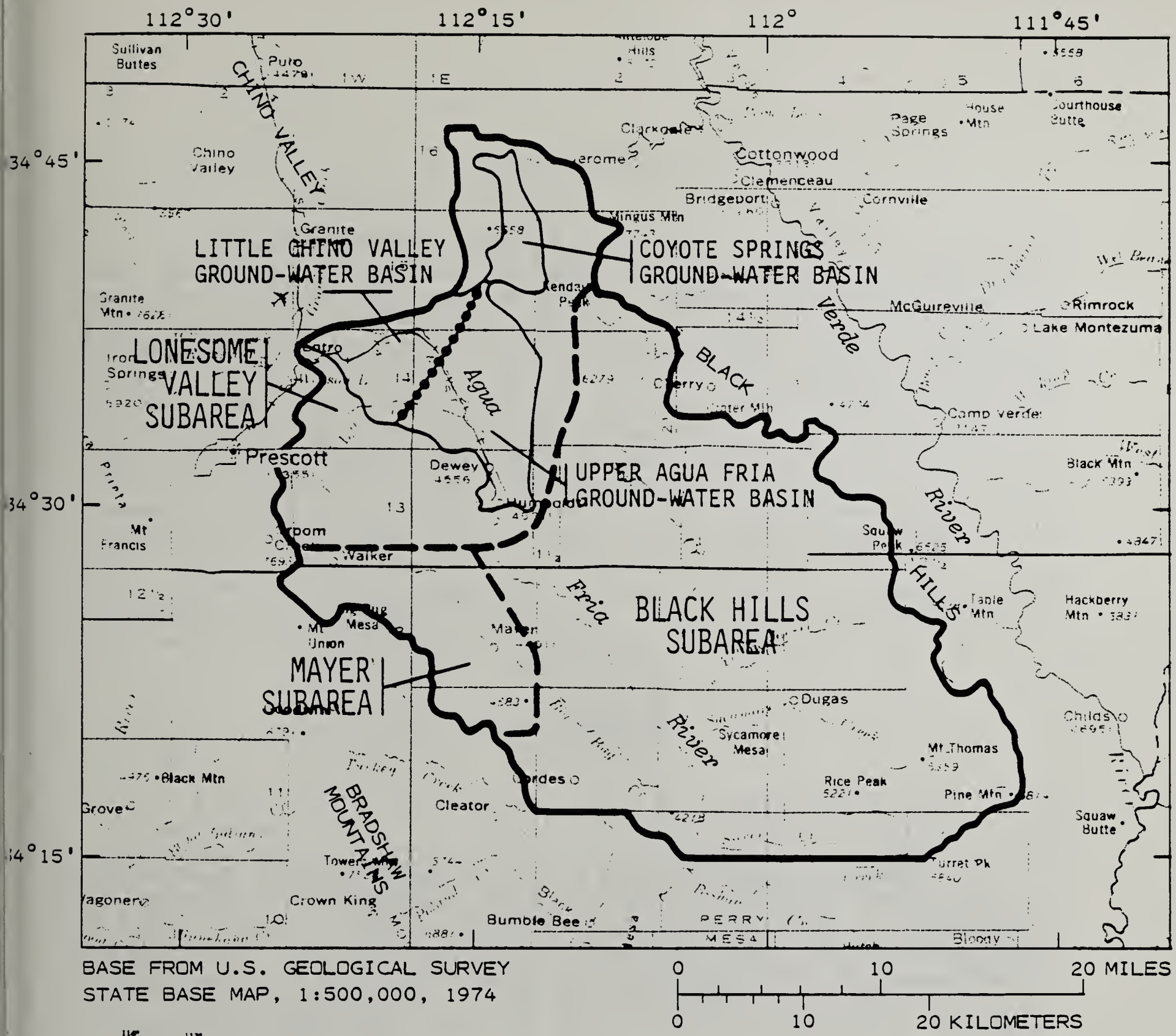
water rights. This appraisal of the water resources was undertaken because of the increased demand for water and the need for information to evaluate effects of future ground-water development. The investigation was done by the U.S. Geological Survey in cooperation with the Arizona Department of Water Resources.

The main source of ground water is the permeable basin-fill, sedimentary, and volcanic rock units that fill the basins and form the major aquifers. The study area contains three ground-water systems or subareas that are separated by nearly impermeable crystalline and foliated basement rocks that prevent significant ground-water flow between the subareas. The subareas are Lonesome Valley, Mayer, and Black Hills (fig. 1).

## Purpose and Scope

The purposes of this investigation were to (1) update the hydrologic data bases; (2) define the ground-water flow systems, (3) define changes in depth to water, potential well yields, and chemical quality of water in major aquifers; and (4) delineate seasonal variations in base flow of the perennial reaches of the Agua Fria River and tributaries. The report describes the ground-water systems, the extent of water-resources development as of 1982, and the effect of development on the ground-water system. The report also provides data that may be used by developers, managers, and landowners to minimize the adverse effects of future ground-water development.

Hydrologic data for this investigation were collected from September 1980 to August 1982. Wells and springs are identified and locations are indicated in accordance with the well-numbering system used in Arizona (fig. 2). Water-level measurements are in table 3; records of selected springs and wells are in tables 4 and 5, respectively, in the hydrologic data section. The ground-water flow systems were defined by use of hydrogeologic maps and cross sections that were prepared on the basis of previous studies, well logs, and field mapping. Potentiometric maps were prepared from water-level measurements and base-flow patterns, and base-flow gains and losses were analyzed. Potential well yields were estimated from pump tests and the extent, thickness, and lithology of the major aquifers. A ground-water budget was estimated for the study area. Chemical quality of ground water and suitability for public supply were determined by analyses of water from selected wells, springs, and base-flow sites. Seasonal variations of base flow of the Agua Fria River and tributaries were determined by measuring base flow in November and December 1980 and June 1981 and by computing flow duration and base flow at the Agua Fria River near Mayer gaging station. The extent of water-resources development and the effect on the ground-water systems were defined by evaluating ground-water recharge and discharge, areas of water-level declines, and volume of ground water in storage.

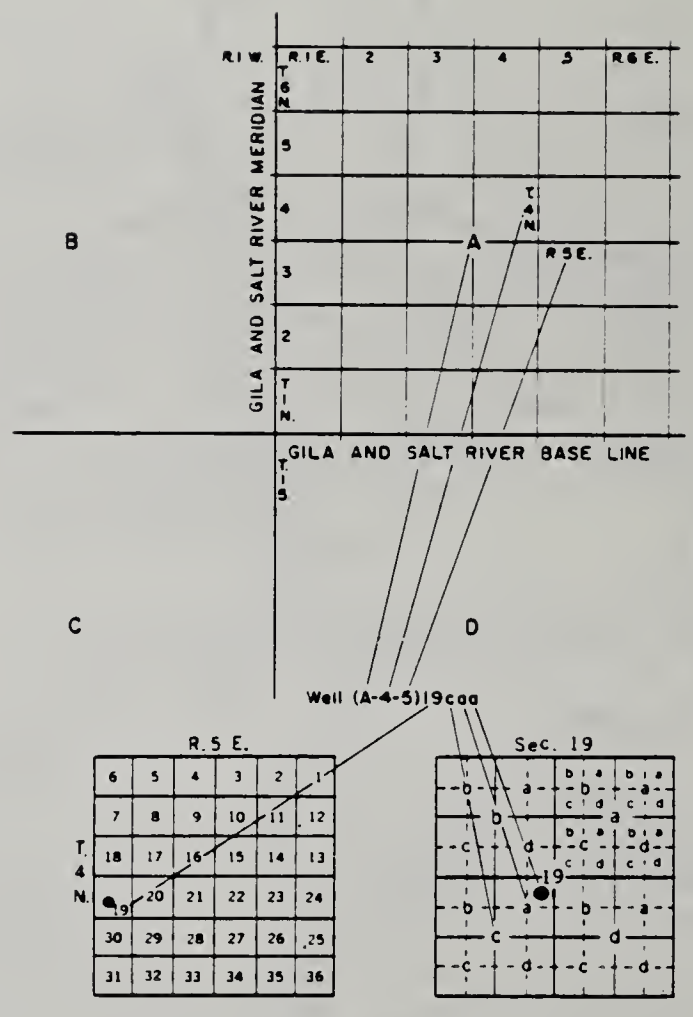


INDEX MAP SHOWING AREA OF REPORT (SHADED)

EXPLANATION

- GROUND-WATER DIVIDE
- BOUNDARY OF GROUND-WATER BASINS
- BOUNDARY OF SUBAREAS
- BOUNDARY OF STUDY AREA

Figure 1.--Area of report and Arizona's water provinces




The well numbers used by the Geological Survey in Arizona are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the State into four quadrants. These quadrants are designated counterclockwise by the capital letters A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters a, b, c, and d after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters also are assigned in a counterclockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (A-4-5)19caa designates the well as being in the NE¼NE¼SW¼ sec. 19, T. 4 N., R. 5 E. Where more than one well is within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.

Figure 2.--Well-numbering system in Arizona.

## Previous Investigations

Detailed geologic reports and geologic quadrangle maps have been published by the U.S. Geological Survey for the study area west of longitude 112°00' W. and parts of the east margin of the Black Hills. The emphasis of most of the reports and maps is a detailed examination of the Precambrian and Tertiary or Cretaceous intrusive, igneous, and metamorphic rocks. A report on the Prescott and Paulden quadrangles (Krieger, 1965) contains detailed descriptions of some sediments deposited in Lonesome Valley. Krieger's report includes a section on ground-water resources near Prescott and contains some well-log data for Lonesome Valley and geologic sections near Prescott Valley, Fain Ranch, Dewey, Humboldt, and the Blue Hills. Schwalen (1967) investigated ground-water conditions in the Little Chino Valley ground-water basin from 1937 to 1965. Littin (1981) investigated the ground-water resources of the Agua Fria River drainage north of latitude 33°45' N. Remick (1983) investigated ground-water conditions in the Prescott Active Management Area, which includes Lonesome Valley.

## Physical Setting

The northern part of the Agua Fria area is part of the Central highlands water province, which is a transition zone between the Plateau uplands and the Basin and Range lowlands water provinces (fig. 1). The study area includes most of the Agua Fria River drainage north of latitude 34°15' N. and the northern part of the Coyote Springs basin in the Verde River drainage (fig. 1). The area is bounded on the northeast by the Black Hills, which extend from Mingus and Woodchute Mountains southeast to Pine Mountain. The boundary along the Black Hills follows the surface-drainage divide. The study area is bounded on the west by the Bradshaw Mountains.

The Agua Fria River flows out of the study area to the south at an altitude of 3,240 ft above sea level. The land surface gradually rises to the northwest to an altitude of 5,000 ft along Highway 89A. The surrounding mountains reach a maximum altitude of about 7,800 ft.

## Climate

Climate in the Agua Fria area is semiarid and is characterized by hot summers and mild winters. Precipitation is predominantly rain but includes some snow in late fall and winter. Most of the rain occurs from mid-July through mid-September (Sellers and Hill, 1974, p. 335). May and June are the driest months. Average annual precipitation is 13.5 in. at Cordes and 12.8 in. at the Prescott airport. Winter storms are characterized by widespread low-intensity precipitation spread over several days. Some of the precipitation is snowfall, which is concentrated

in the higher parts of the Bradshaw Mountains and the Black Hills. Summer precipitation generally occurs as short-lived intense thunderstorms from mid-July through mid-September. Evapotranspiration rates are much higher than the annual precipitation rate. The estimated annual lake evaporation is about 60 to 62 in. (Anderson, 1976, p. 24).

## Acknowledgments

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# ROCK UNITS AND THEIR HYDROLOGIC SIGNIFICANCE

In the study area ground water occurs in several individual geologic formations. For purposes of this study, the formations are combined into hydrologic rock units that have similar ground-water storage and transmissive properties. Major factors considered in assigning a formation to a unit are potential well yield, saturated volume, role of the formation in transmitting water from recharge area to discharge area, areal extent, similarity of lithology, and consistency with previous geologic investigations. The extent of the units was delineated by compiling available geologic maps, photointerpretation, field mapping, and interpretation of drillers' and geologists' logs. The units, in order from oldest to youngest, are basement, marine, sedimentary, volcanic, and basin fill.

## Basement Unit

The common hydrologic property of the basement rocks is a minimal storage and transmission of water except by means of secondary permeability—fractures and decomposed or weathered zones. The secondary permeability and porosity typically decrease with depth. Yield of water to wells, depth to water, and chemical quality of water are highly variable depending on the degree of local fracturing and chemical alteration of primary rock components. The basement unit is present beneath the other units and separates ground-water flow systems that occur in the permeable rock units. The basement unit forms the floor of the individual ground-water basins. Base flow is maintained in stream reaches that are cut into basement rock because the unit prevents infiltration.

The basement unit is made up of a wide variety of crystalline or foliated igneous and metamorphic rocks that generally are dense, nonporous, and nearly impermeable. The most common rock types are

granite, diorite, gabbro, schist, metavolcanics, and metasediments. The rocks generally are Precambrian except for a few Cretaceous and Tertiary granitic bodies.

The basement unit generally is exposed at the surface in the Bradshaw Mountains. The outcrop area includes a large part of the Black Hills south of Mingus Mountain and extends southwestward to Mayer and Poland Junction. Basement outcrops also occur in an area south of Cordes Junction and in the southeast end of the Black Hills (pl. 1). In a zone along the northeast margin of the Black Hills, the unit is exposed in areas where the overlying volcanic, sedimentary, and marine units have been eroded.

## Marine Unit

The marine unit is made up of four consolidated sedimentary marine formations of Paleozoic age that store and transmit water primarily in fractures, weathered zones, and solution cavities. The formations from oldest to youngest are Tapeats Sandstone, Martin Formation, Redwall Limestone, and Supai Formation.

The marine unit was deposited on basement rocks in a narrow band that extends from near the north end of Coyote Springs ground-water basin along the margin of the Black Hills to Pine Mountain. The unit is overlain by younger volcanic and sedimentary units and is exposed along side slopes, canyon walls, and canyon bottoms where the overlying units have been extensively eroded. Distribution and thickness of the unit are variable because it was deposited on an irregular basement-rock surface and was eroded before being covered by younger rocks. The unit ranges from 0 to about 1,000 ft thick. Probable extent of the marine unit beneath the volcanic rocks in the Black Hills and the basin fill in the Coyote Springs basin is shown on plate 1. The Tapeats Sandstone and Martin Formation extend from the north end of Coyote Springs basin along the margin of the Black Hills to Pine Mountain. The Redwall Limestone is present near Woodchute and Mingus Mountains but thins to the southeast and occurs only as scattered outcrops near Squaw Peak. The Supai Formation is present only in the northern part of the study area near Woodchute and Mingus Mountains.

## Sedimentary Unit

The sedimentary unit forms the major aquifer in the study area and contains large volumes of ground water in storage. The unit is widely distributed in the study area (pl. 1). The sedimentary unit consists of continental sediments of Tertiary age assigned to the Hickey

Formation and similar sediments of late Tertiary age in Lonesome Valley. Generally, all the sediments that underlie or are interbedded with volcanic rocks are included. The unit partly fills the structural trough that forms Lonesome Valley and is interbedded with volcanic rocks at Prescott Valley, Humboldt, Mayer, Cordes, Spring Valley, and Cordes Junction. The unit underlies volcanic rocks near Cienega Creek, along Ash Creek, and near the Agua Fria River in Tps. 10 and 11 N., R. 3 E. The sediments were deposited before, during, and after deposition of the volcanic rocks. Basin fill was deposited on the sedmentary unit after movement along high-angle faults formed the present-day basins. The contact between the two units is poorly defined, and, in some places, small areas of basin fill are included with the sedimentary unit.

The sedimentary unit consists of cobble gravel, sand, silt, clay, marl, and limestone that are weakly to moderately consolidated. The clasts are angular to well rounded and are poorly to moderately sorted; sorting varies from one bed to another and from place to place. Clasts are derived from volcanic, marine, and basement rocks. Most of the sedimentary unit contains all three types but one type generally is predominant in a local area. The unit varies from greenish to yellowish gray to gray to brown depending on the color of the most common particle type. Fine-grained beds in the Fain Ranch-Dewey area are light orange to light brown.

The sedimentary unit includes a poorly sorted basal gravel in much of the study area. Basal gravel includes sand and commonly contains boulders and cobbles. Clasts are angular to well rounded. The material is weakly to firmly consolidated and locally is cemented with caliche (calcium carbonate) near the underlying marine unit. The clasts are derived mainly from basement rocks, lesser amounts from marine rocks, and minor amounts from volcanic rocks. The gravel commonly contains basement-rock clasts that originated south and west of the study area.

## Volcanic Unit

The volcanic unit includes the volcanic members of the Hickey Formation of Tertiary age. The unit covers much of the area around Woodchute and Hickey Mountains and substantial areas in the Black Hills and caps mesas and hills in the Bradshaw Mountains (pl. 1). Smaller outcrops occur at Glassford Hill, Humboldt, and in the area between Mayer and Cordes. The unit commonly is interbedded with the sedimentary unit.

The volcanic unit consists of basaltic lava flows, cinder cones, tuff, and water-deposited interbeds of basaltic cinders and gravel. The lava flows typically are 10 to 50 ft thick, generally are vesicular, and have massive interior zones and blocky broken tops. Columnar jointing

and fracturing are common. Calcite generally fills fractures or cements brecciated parts of the flows. The basalt is light to dark gray. Water-deposited volcanic sediments are composed of ash, cinders, scoria, and basaltic gravel. Volcanic sediments are light brown to orange red and are weakly to moderately cemented. The material is well bedded to massive and is moderately sorted. The beds contain abundant sand- and gravel-size particles but little silt and clay. The volcanic sediments are most abundant in the Black Hills where they make up more than half the exposed thickness of the volcanic unit.

### Basin-Fill Unit

Basin fill is the youngest and most transmissive unit mapped in the study area and stores and transmits large quantities of ground water. The unit serves as a conduit for water from direct runoff that infiltrates readily through the sand and gravel that form the channel bottoms and flood plains of streams and washes. The unit is composed of gravel, sand, silt, and clay eroded from all the older units. Basin fill was deposited after the major Basin and Range tectonic movements uplifted the highland areas and formed basins in the downdropped areas. The unit includes river wash, alluvium, flood-plain and terrace gravels, pediment gravels, and alluvial-fan and talus gravels, all of Quaternary age. Quaternary and Tertiary alluvial-fan gravels, fanglomerate, older gravel, and some sedimentary rocks previously assigned to the Hickey Formation are also included.

Basin fill is composed mainly of unconsolidated to moderately consolidated gravel and sand and includes significant quantities of boulders, cobbles, silt, and clay. The material is moderately sorted to unsorted. The clasts are angular to well rounded; most are subangular and subrounded. Roundness generally varies by lithology; well rounded volcanic cobbles are included with subangular cobbles and gravel of wear-resistant basement rocks. The composition varies according to source area, which is either the Bradshaw Mountains or the Black Hills; in many places, the unit contains rocks derived from one source area. The unit is tan to gray, and weathered exposures commonly are reddish in color. Basin fill is weakly to firmly consolidated and cemented with travertine (calcium carbonate) near Mayer. The large amount of carbonate indicates that the rocks may be part of the sedimentary unit, although the unit is mapped as basin fill. Moderately consolidated basin fill is deposited on basement rocks in the Blue Hills; however, this material may be part of the sedimentary unit.

## GEOLOGIC STRUCTURE AND AQUIFER GEOMETRY

Geologic structure and the distribution, lithology, and water-bearing characteristics of the hydrologic rock units determine the location

and geometry of the aquifers. Basin-and-range faulting and warping created downdropped structural basins that contain the aquifers. Subsequent deposition within the basins and development of the surface-drainage pattern influenced the location of the present-day ground-water flow systems. The streams and washes form the main recharge and discharge areas of the flow systems. The study area is divided into three ground-water subareas—Lonesome Valley, Mayer, and Black Hills—that are separated by low-permeability basement rocks that prevent significant subsurface flow between them.

## Lonesome Valley

The Lonesome Valley subarea includes the part of Lonesome Valley southeast of State Highway 89A and the Coyote Springs ground-water basin, which is along the east side of the valley (fig. 1). Lonesome Valley is the local name for the southeast end of Little Chino Valley.

Little Chino Valley, Lonesome Valley, and Coyote Springs ground-water basin are parts of a structural trough (Krieger, 1965, p. 66), which is filled with basin-fill, sedimentary, and volcanic rock units. These rock units form the major aquifer (pl. 2). Coyote Springs ground-water basin is separated from the main part of Lonesome Valley by the basement rocks of the Indian Hills (pl. 1). Movement along high-angle faults created the trough between the Bradshaw Mountains to the southwest and the uplifted Black Hills to the east. The floor and sides of the structural trough are formed mainly from low-permeability basement rocks. The trough extends about 28 mi from Humboldt to the northwest. The east side of the trough is bounded by the Coyote fault that forms the west edge of the Black Hills. The fault extends from a point 3 mi east of Humboldt to the north boundary of the study area. Vertical movement on the fault was estimated by Krieger (1965) to range from 0 ft at Humboldt and at the north boundary of the study area to about 1,200 ft approximately 1 mi south of State Highway 89A. The southwest margin of the trough appears erosional, although faults may be covered by basin fill.

Basin-fill, volcanic, and sedimentary units form the major aquifer in the Lonesome Valley subarea. Although some basin fill and volcanic rocks are saturated, the sedimentary unit forms most of the aquifer volume. The approximate margin of the major aquifer is shown on plate 1. The margin location is based on well-log data or is estimated from geologic information. Saturated thickness is estimated to be at least 100 ft.

Basin fill forms a thin veneer that covers the sedimentary unit in most of the subarea. Basin fill forms the channel bottoms, flood plains, and terraces of Lynx Creek, Agua Fria River, and other larger

canyons and washes and includes the fan gravel at Blue Hills. Low places near the center of the subarea along the Agua Fria River are covered with basin fill that contains substantial amounts of material eroded from the sedimentary unit. Basin fill probably is less than 100 ft thick in most of the main part of Lonesome Valley. Wells close to the Agua Fria River may withdraw some water from basin fill. The unit yields small volumes of water to wells in the Blue Hills where it is deposited on basement rocks; in much of Lonesome Valley, the unit is dry. Basin fill forms the main aquifer in the Coyote Springs ground-water basin. The unit is thin in much of the basin but may be several hundred feet thick near the south and east edges.

Lava flows are interbedded with the sedimentary rock unit at Prescott Valley. The flows extend from Glassford Hill at least 2 mi to the northeast and make up about 20 percent of the aquifer volume penetrated by wells in T. 14 N., R. 1 W. The uppermost flow is 30 to 100 ft thick and is encountered at a depth of about 450 ft; additional flows exist at depth in the unit. The flows are not continuous throughout the area; the uppermost flow was not penetrated by well (B-14-01)10acd but was penetrated by wells to the south and east. The flows cause reduced well yields and retard the vertical movement of ground water.

The sedimentary rock unit forms most of the aquifer volume in the main part of Lonesome Valley (pl. 1). The unit thickens from 0 ft at Humboldt to 1,160 ft in sec. 11, T. 13 N., R. 1 E.; is more than 700 ft thick in the vicinity of Prescott Country Club and Lynx Creek; and probably is more than 850 ft thick at Fain Ranch. The unit, which includes lava flows, probably is more than 1,000 ft thick at Prescott Valley. The thickness of the unit in the central part of Lonesome Valley is unknown but probably exceeds 1,000 ft.

The unit is coarse grained in the vicinity of Prescott Valley and Humboldt and becomes fine grained at Fain Ranch and toward the central part of the valley. Boulders and cobbles are common in the unit at Prescott Valley. At Dewey and Humboldt, the upper 50 to 150 ft of the unit is composed mainly of silt and clay, which thicken to as much as 500 ft at Fain Ranch.

Surface drainage and ground-water movement in the ancestral Lonesome Valley subarea was to the north and northwest into the Verde River. Headward erosion by the Agua Fria River and its tributaries moved the drainage divide to its location along State Highway 89A and in the Coyote Springs ground-water basin (Krieger, 1965, p. 102). Down-cutting by the Agua Fria River stripped away part of the sediments in the southeast end of the subarea and allowed direct runoff and part of the ground water to drain to the southeast. The Agua Fria River has cut down to basement rock at Humboldt; basement rock also outcrops at the land surface a short distance to the east and southeast of the river. A volcanic flow underlain by a thin layer of sedimentary rock forms a

barrier to subsurface flow on the west side of the river. The effect of the low-permeability rock units forces ground water to the surface.

## Mayer

The Mayer subarea includes most of the Big Bug Creek drainage from Walker to 3 mi southeast of Mayer. The major aquifer extends for 2.5 mi along Big Bug Creek at Mayer (fig. 1). The ancestral valley was cut on low-permeability basement rocks and then was partly filled with older basin-fill gravel. The older gravel extends from at least 2 mi northeast of Poland Junction approximately along the present alignment of Big Bug Creek to southeast of Mayer where it appears to be deposited on the sedimentary unit (pl. 1). The older gravel occurs below stream level at Mayer. Younger basin-fill terrace deposits and gravel are deposited on the older gravel and basement rocks near and along Big Bug Creek and may extend far enough below stream level to yield water to wells. The older gravel is consolidated and cemented with caliche and travertine on the northeast side of Big Bug Creek at Mayer.

Ground water occurs in the basin-fill, sedimentary, and basement rock units in the Mayer subarea. Near Poland Junction, water is obtained from the secondary permeability features in the basement rocks. Big Bug Creek has cut down through and drained the older gravel at Poland Junction and downstream to about 2.5 mi above Mayer. The lowest few feet of the older gravel may be saturated; however, most wells yield water from basement rocks. Water is obtained from older basin-fill gravel and possibly younger gravel along Big Bug Creek at Mayer. Direct runoff along Hackberry Creek recharges basin-fill and sedimentary rocks south of Mayer. Some water may move northward through the units and into Big Bug Creek, but the low hydraulic conductivity of the sedimentary rocks prevents significant flow.

## Black Hills

The Black Hills subarea includes most of the southeastern half of the study area including the southwest slopes of the Black Hills from Pinto Mesa to Pine Mountain. The geometry of the Black Hills subarea resulted from the formation of a structural basin and subsequent erosion and development of a surface-drainage network.

Hydrologic rock units that form the major aquifer are basin fill, volcanic, sedimentary, and marine. The basement unit underlies the entire subarea and crops out at the surface in several places (pl. 1). Various combinations of the units are present in different parts of the subarea. Along the west side, three units form the aquifer—basin fill, volcanic, and sedimentary (pl. 1). The marine unit underlies the volcanic rocks along the eastern part of the Black Hills.

Location of the approximate margin of the major aquifer is based on an estimated saturated thickness of at least 100 ft (pl. 2). Thickness data are available from a few well logs; in most of the Black Hills subarea, the position of the aquifer margin was estimated from geologic information.

The thickness and distribution of the four units that form the aquifer vary because each unit was deposited on an erosional surface cut on the underlying units. The marine unit was deposited on an erosional surface of rolling hills cut on basement rocks and probably was as much as 1,000 ft thick. In time, the area tilted to the northeast and streams eroded away all but a band of the marine rocks along the east margin of the Black Hills from Pine Mountain north and northwest toward Mingus and Hickey Mountains.

During Tertiary time, a discontinuous layer of gravel was deposited in the subarea and formed the basal gravel of the sedimentary unit (Wadell, 1972, p. 10). The gravel was eroded from areas mainly to the south and west of the subarea and deposited in stream channels, flood plains, and valleys. Above the basal gravel, sediments that originated outside the subarea are interbedded with lenses and beds of locally derived material.

During late Tertiary time, several hundred feet of basaltic lava flows and volcanic sediments were deposited over most of the subarea except in an area south and southwest of Cordes Junction. Lava flows are dominant in the northern and western parts of the subarea and are interbedded with as much as 250 ft of volcanic sediments in the Black Hills.

After a period of erosion, basin-fill gravel was deposited in a 3- to 5-mile-wide valley cut into the volcanic unit along the west side of the subarea (pl. 1). Drainage may have been from the north because clasts of marine and basement rocks that originated in the Mingus Mountain area have been found northeast of Spring Valley (Anderson and Blacet, 1972a, p. 55; 1972b, c). The gravel was more than 300 ft thick in places. During or after the deposition of the basin-fill gravel, the Black Hills were tilted to the west and southwest in the east side of the subarea and to the south in the northern part. The rock units were tilted to the east along the west side and to the northeast near Cordes and Spring Valley. The dips are small and resulted in a bowl-shaped basin gently tipped toward the south.

Basin-fill, volcanic, and sedimentary rock units form the major aquifer from Spring Valley northward along the west side of the basin to T. 13 N., R. 2 E. (pl. 1). The saturated thickness may be as much as 250 ft. Basin fill overlies volcanic rocks beginning about 0.5 mi northwest of Spring Valley along Big Bug Creek and extends eastward to Cordes Junction, northward across the Agua Fria River, and southward to Cordes. The basin fill thins to the south, and basement rocks crop out along most of the south edge of sec. 16, T. 11 N., R. 2 E.

Saturated thickness of the basin fill is about 100 ft at a point half a mile west of Interstate 17 and thins to nearly zero near the highway. Volcanic rocks crop out west of Spring Valley, continue east and north beneath the basin fill, and reappear at Cordes Junction and near the Agua Fria River. The volcanic rocks are the main water-bearing unit near the intersection of State Route 69 and Interstate 17 and northeast to the Agua Fria River. In much of the area around Cordes Junction, the volcanic rocks are dry or absent and water is obtained from the sedimentary rocks. Sedimentary rocks are present beneath the volcanic rocks from near the west edge of Spring Valley east to Cordes Junction where they are exposed at the surface and north to the Agua Fria River.

The aquifer near Orme Ranch is composed of basin-fill, volcanic, and sedimentary rocks to the west and volcanic and sedimentary rocks to the east and northeast. Most water is pumped from basin fill that forms the flood plain of Ash Creek.

Younger basin-fill gravel is the main water-bearing unit along the flood plain of the Agua Fria River in secs. 22 and 27, T. 12 N., R. 2 E., and is underlain by sedimentary rocks and possibly volcanic rocks. The saturated thickness of the combined basin-fill and sedimentary units is as much as 370 ft.

Volcanic rocks are the main water-bearing unit from Ash Creek and Agua Fria River eastward to the west margin of the Black Hills. The volcanic rocks are thin along a several-mile-wide band that extends from Cienega Creek to Pine Mountain, and underlying basement and marine rocks are exposed in canyon bottoms and walls. West of the band of basement-rock exposures, the volcanic rocks thicken and several hundred feet of the unit may be saturated.

The main water-bearing unit near Pine Mountain is the marine rocks that are exposed in canyon walls and bottoms or are covered by volcanic rocks that cap the intercanyon mesas and ridge tops. The volcanic and marine rocks dip to the west and north. The saturated thickness of the marine unit is highly variable; many areas probably are dry. The aquifer near Cienega Creek is formed by sedimentary rocks that are consolidated and contain significant amounts of fine-grained tuff.

## GROUND-WATER HYDROLOGY

The source of ground water and surface water in the northern part of the Agua Fria area is precipitation that falls as rain in the summer wet season and as rain and snow during the winter storm periods. The precipitation is concentrated in the higher altitude areas, and most is lost to evapotranspiration. Some precipitation becomes direct runoff, a part of which infiltrates through the soil and alluvium into the permeable rocks and eventually recharges the ground-water system.

Streams and washes convey direct runoff in their channels, recharge water to the aquifers, and discharge water from the aquifers as base flow. Water leaves the study area mainly as surface flow in the Agua Fria River and as subsurface flow to the northwest in the Little Chino Valley ground-water basin.

Ground water is the source of all public water supplies and much of the water used for irrigation. Several ranches, which divert surface water from the Agua Fria River and its tributaries, have wells to provide irrigation water during periods of low or no flow. Future increases in water demand for industry and the growing population will be met from ground water because no alternate sources are presently available.

Streams and washes of the drainage system form the main recharge and discharge areas in the three subareas of the study area. Each subarea contains a distinct ground-water flow system that consists of source areas for recharge; space for storage and movement toward one or more discharge areas; and discharge by means of pumping from wells, spring flow, base flow in a stream reach, or evapotranspiration.

## Lonesome Valley

### Ground-Water Flow System

The ground-water flow system in the Lonesome Valley subarea is divided into three parts: Coyote Springs ground-water basin, Little Chino Valley ground-water basin (Schwalen, 1967), and Upper Agua Fria ground-water basin (pl. 2). Coyote Springs ground-water basin lies to the east of Little Chino and Lonesome Valleys and is separated from the main part of Lonesome Valley by low-permeability basement rocks of the Indian Hills. Little Chino Valley ground-water basin extends from a northeast-trending ground-water divide northward beyond the study area (pl. 2). Upper Agua Fria ground-water basin extends from the ground-water divide southeastward to Humboldt. The approximate location of the ground-water divide is from 1 to 4 mi southeast of the surface divide between the Verde River and Agua Fria River drainages.

Recharge.--The main source of recharge in Lonesome Valley is infiltration of direct runoff into the channel bottoms and flood plains of the washes and streams that drain the highlands surrounding the valley. The water moves downward and eventually recharges the aquifers below. Most of the highland areas are underlain by basement rocks that transmit and store only small quantities of water. Most of the infiltration occurs after the direct runoff leaves the mountain front, although underflow may be significant in those canyons that contain sufficient volumes of basin-fill alluvium. Lynx Creek probably is the largest source of recharge for the

Upper Agua Fria and Little Chino Valley ground-water basins because of its large drainage area and the nature of its bed material. The alluvium along Lynx Creek is highly permeable owing to past dredging and hydraulic-mining operations that flushed away fine-grained material. A significant part of the direct runoff infiltrates and recharges the ground-water system beneath Lynx Creek. About one-third of the infiltrated water is estimated to recharge the Little Chino Valley basin, and the rest recharges the Upper Agua Fria basin assuming infiltration is approximately proportional to channel length on each side of the ground-water divide. A significant source of recharge in the main part of the valley is from infiltration of direct runoff along Coyote Wash and Yaeger Canyon, which drain the southern part of the Coyote Springs basin. Direct runoff along the Agua Fria River may make a small contribution to the system near Prescott Valley and a moderate contribution in the area of Fain Ranch, Dewey, and Humboldt. Recharge to the Upper Agua Fria basin also comes from infiltration of direct runoff along Clipper Wash, Green Gulch, and other washes that drain the northeast side of the Bradshaw Mountains.

The source of recharge in Coyote Springs basin is infiltration of direct runoff into the beds of several washes that drain the area of Hickey and Woodchute Mountains. Infiltration of precipitation into basin-fill, volcanic, and marine rocks where the rock units crop out also recharges the basin. Most of the recharge probably occurs after the direct runoff crosses the Coyote fault because basement rocks are close to the surface on the east side of the fault.

Movement.--Ground water in the northern part of the Coyote Springs basin moves southwestward into the Little Chino Valley basin or northward into the Verde River drainage (pl. 2). Water in the southern part of the Coyote Springs basin moves through gaps in the Indian Hills southwestward into the Little Chino Valley and Upper Agua Fria basins. Most of the water probably moves as underflow along Coyote Wash. Ground water recharged along Lynx Creek moves northward out of the study area through the aquifer of the Little Chino Valley basin or eastward through the Upper Agua Fria basin. Ground water recharged along small washes that drain the west side of the Black Hills moves southward and southwestward to the vicinity of the Agua Fria River and then southward toward the outlet of the basin at Humboldt.

Discharge.--Ground water discharges from the Upper Agua Fria basin as base flow in the Agua Fria River at the lowest point of Lonesome Valley at Humboldt. The flow begins about 1.1 mi above Humboldt and increases downstream to near Lazy River Drive (pl. 3, site 1). The river probably is perennial at the Lazy River Drive crossing where flow measurements from 0.84 to 1.61 $ft^3/s$ were made during the 1981 water year. Ground water is pumped from public-supply, irrigation, commercial, and domestic wells in the Upper Agua Fria basin and mainly

from public-supply wells near Prescott Valley in the Little Chino Valley basin.

## Occurrence of Ground Water

Depth to water.--Depth to water in Upper Agua Fria basin ranges from less than 50 ft along the Agua Fria River from the mouth of Lynx Creek to Humboldt to more than 300 ft along the east edge of the basin. Depth to water in the Little Chino Valley basin is less than 100 ft along much of the flood plain of Lynx Creek to more than 500 ft near the east side of Glassford Hill. Depth to water in the Coyote Springs basin ranges from less than 50 ft along the southwest side to more than 300 ft along the east side.

Potential well yields.--Well yields depend on the hydraulic conductivity of the aquifer; the saturated thickness open to the well bore; and how the well was drilled, constructed, and developed. Well yields near or outside the margin of the major aquifer may be too small for public or irrigation supplies. Well yields may be sufficient for stock or domestic supplies where local aquifers exist or the basement rock is fractured. Potential well yields were estimated from pump tests conducted for water companies and private parties and from the extent, thickness, and lithology of the major aquifers.

Potential well yields in the main part of Lonesome Valley range from 50 to 2,000 gal/min (pl. 2). Larger existing wells yield from 100 to 1,750 gal/min. Specific capacities range from 0.53 to 19.9 (gal/min)/ft. Well yields are greatest near Prescott Valley. Well yields are smaller in the area that extends from Fain Ranch to Humboldt; discharges range from 100 to 1,000 gal/min. Specific capacities range from 0.53 to 5.6 (gal/min)/ft. Potential well yields are more than 100 gal/min near Dewey and Humboldt. Well yields in the Blue Hills are normally less than 10 gal/min and may be as low as a few gallons per hour where water occurs in basement rock. The yields are small because the basin-fill unit is thin, consolidated, poorly sorted, and contains large amounts of cobbles and boulders.

Potential well yields are designated on plate 2 by zones that have overlapping ranges of values because of variations in water-bearing characteristics of the aquifer and availability of data. Local areas within the zones may yield water at rates greater than or less than the indicated values. The zones are a general guide and are intended to be used to illustrate favorable areas for developing water supplies. Obtaining the maximum or optimum well yield at a particular site will require proper exploration and evaluation of the site and optimum design, construction, and development of wells.

Ground water in storage.--About 800,000 acre-ft of water is in storage in the upper 200 ft of the major aquifer in the main part of

Lonesome Valley. About 300,000 acre-ft is stored in that part of the Little Chino Valley ground-water basin in the study area, and about 500,000 acre-ft is stored in the Upper Agua Fria ground-water basin. The volume of water in storage was estimated by delineating the area where the aquifer is at least 200 ft thick and multiplying that volume of aquifer by an assumed specific yield of 0.12. Saturated-thickness data are inadequate to estimate storage at greater depths, but an additional several hundred thousand acre-feet may be in storage. Saturated-thickness data in the Coyote Springs ground-water basin are inadequate to estimate ground water in storage; however, the volume is much smaller than that stored in the main part of Lonesome Valley.

## Mayer

### Ground-Water Flow System

The main source of recharge in the Mayer subarea is infiltration of direct runoff into the bed and flood plain of Big Bug Creek. The general movement of ground water is parallel to and at about the same gradient as Big Bug Creek (pl. 2), which establishes the altitude for the local potentiometric surface. Ground water occurs at land surface where the stream channel is cut into basement rock downstream from Mayer. Flow of a few gallons per minute of water was observed at that point in December 1980, but the stream was dry in most areas in June 1981. Presence of cottonwoods and other water-loving plants indicate shallow ground-water levels along the creek. Base flow is only a few acre-feet per year; most of the ground water probably is pumped by domestic and public-supply wells or is discharged by evapotranspiration along Big Bug Creek.

Direct runoff along Hackberry Creek recharges sedimentary rocks south of Mayer. Small amounts of water may move northward through the rocks and into Big Bug Creek, but the low hydraulic conductivity of the rocks prevents a significant flow.

### Occurrence of Ground Water

Ground water occurs in basin-fill, sedimentary, and basement rocks in the Mayer subarea. Depth to water ranges from less than 15 ft near Big Bug Creek to less than 200 ft near Poland Junction and generally is less than 100 ft near Mayer. The potential well yield is 5 to 100 gal/min where basin fill forms the major aquifer. Potential well yields generally are small owing to low permeability of basement rocks and cemented older basin fill or the small saturated thickness of basin fill.

## Black Hills

### Ground-Water Flow System

The ground-water flow system of the Black Hills subarea is controlled by geologic structure, aquifer geometry and characteristics, and the location of streams and canyons. Aquifers are recharged by direct runoff that infiltrates through streambeds and flood plains and by infiltration of precipitation on the outcrops of rock units that form the aquifer.

Outcrops of basement rocks downstream from the mouth of Sycamore Creek prevent ground water from entering the Agua Fria River. The nearly impermeable rock forces ground water to the surface where it discharges into the river as base flow. This base-flow reach of the river establishes the lowest altitude of about 3,500 ft for the potentiometric surface for most of the western and northern parts of the subarea. Local position and general slope of the potentiometric surface are defined by base-flow reaches of the streams.

Direct runoff infiltrates and eventually recharges the major aquifer along Big Bug Creek, Agua Fria River, and Yarber Wash on the west and Osborne Spring Wash and Ash Creek on the north. Cienega Creek, Little Ash Creek, Sycamore Creek, Indian Creek, and Silver Creek drain the southwest slopes of the Black Hills. Direct runoff and base flow leave the basin in the Agua Fria River.

Recharge.--The main source of recharge is from direct runoff that infiltrates into the channel bottoms and flood plains of the washes and streams that drain the highland areas surrounding the basin. The two largest sources of recharge are along the channels of Big Bug Creek and Agua Fria River; lesser amounts infiltrate the channels of Ash Creek, Osborne Spring Wash, and other larger streams and washes. The main source of recharge in the area of Spring Valley and Cordes Junction is from infiltration of rainfall and direct runoff into basin-fill and volcanic rocks along Big Bug Creek. Recharge also occurs where volcanic, sedimentary, and marine rocks crop out.

Movement and Discharge.--Water recharged along streams or rock outcrops moves generally downdip through the aquifer and discharges as base flow in streams or is pumped from wells. The main concentration of base-flow discharge is in the Agua Fria River near the mouths of Sycamore and Ash Creeks for about 1 mi above Sycamore Creek.

Ground water moves eastward and northeastward away from Big Bug Creek through the basin-fill, volcanic, and sedimentary rocks and discharges into two reaches of the Agua Fria River from a point in the

southern part of sec. 1, T. 11 N., R. 2 E., downstream to the mouth of Sycamore Creek. Part of the ground water is pumped for public supply at Spring Valley and mainly for public-supply and commercial use at Cordes Junction. A small volume of ground water probably moves away from Big Bug Creek to the south and west near Spring Valley through the basin-fill, volcanic, and sedimentary rocks (pl. 2). Springs and seeps in sedimentary rocks discharge ground water beneath the volcanic rocks about 3 mi to the southwest.

Near Orme Ranch, ground water moves toward Ash Creek through the volcanic and sedimentary rocks from the northeast and through the basin-fill, volcanic, and sedimentary rocks from the northwest. Ground water moves southward through the basin fill near and parallel to Ash Creek. In Ash Creek, ground water discharges as base flow or is pumped for irrigation in secs. 17 and 20, T. 12 N., R. 3 E.

In sec. 26, T. 12 N., R. 2 E., ground water moves through the aquifer southward toward the Agua Fria River and then southeastward parallel to the general course of the river. Part of the water eventually appears as base flow in the Agua Fria River above Sycamore Creek.

In the Black Hills, ground water generally moves toward the southwest and discharges into Ash Creek, major canyons, or the Agua Fria River. Near Pine Mountain, ground water moves northward and westward and issues from Nelson Place Springs, Bee House Canyon Springs, and smaller springs located higher in exposures of the marine rock unit (pl. 2). Some water may move into the alluvium and discharge into Sycamore Creek. The water probably moves mainly along fractures enlarged by solution in the Martin Formation. The two larger springs issue from the base of the Martin Formation above the Tapeats Sandstone. Ground water in the Cienega Creek area moves toward or approximately parallel to the stream. The water is pumped locally, discharges to Cienega Creek as base flow, or is lost to evapotranspiration.

## Occurrence of Ground Water

Depth to water.--Depth to water in the Black Hills subarea ranges from less than 20 ft near the base-flow reaches of streams to as much as 500 ft in higher locations away from streams or on mesas between major canyons. Depth to water probably is less than 20 ft below stream level in the flood plain of Ash Creek in secs. 8, 17, and 20, T. 12 N., R. 3 E. Along Big Bug Creek, ground water occurs at a depth of less than 20 ft below the channel where permeable sand and gravel allow streamflow to infiltrate into the volcanic and sedimentary rocks or the basin fill.

Potential well yields.--Potential well yields in the Black Hills subarea vary greatly owing to the variation in distribution and saturated thickness of the rock units that form the major aquifer (pl. 1). The basin fill is the most productive unit; the volcanic and sedimentary rocks yield moderate amounts of water, and the marine rocks yield small amounts of water to wells. The probable range in well yields is 50 to 1,000 gal/min for basin fill, 5 to 100 gal/min for volcanic and sedimentary rocks, and less than 10 gal/min for marine rocks.

Well yields near or outside the margin of the major aquifer may be too small for public or commercial water supplies. Well yields may be sufficient for stock or domestic water supplies where local aquifers exist or the basement rock is fractured. In some areas, the basement rocks are dry or potential well yields are a few gallons per hour.

Potential well yields near Cordes Junction range from a few gallons per minute from consolidated and cemented sedimentary rocks to about 100 gal/min from volcanic and sedimentary rocks. In the Spring Valley area, well yields may be more than 100 gal/min if the basin-fill, volcanic, and sedimentary units are all tapped.

Two wells yield 625 and 210 gal/min from basin fill in the flood plain of Ash Creek. Saturated thicknesses are 37 and 12 ft, respectively. Potential yield in that area is at least 100 gal/min if 20 ft or more of the saturated basin fill is penetrated.

Near Cienega Creek, potential yield of wells that tap the sedimentary rocks is a few gallons per minute owing to low hydraulic conductivity of the unit. Low hydraulic conductivity is inferred from the steep ground-water gradient to and the small discharge from several springs issuing from sedimentary rocks in sec. 8, T. 13 N., R. 4 E., adjacent to the study area. Several wells obtain water from an area of basin fill of less than 2 $mi^2$ in the vicinity of sec. 10, T. 13 N., R. 3 E. One well yields 900 gal/min. The saturated thickness probably is less than 100 ft.

Ground water in storage.--The rock units that form the major aquifer vary in thickness, areal extent, and contribution to total volume of ground water in storage from place to place in the basin. An estimate was made on the basis of 100 ft of saturated thickness for the major aquifer. The specific yield of the basin-fill unit is assumed to be 0.12; the specific yield of the volcanic, sedimentary, and marine rocks considered as a combined unit is assumed to be 0.03. The resulting estimate of the total volume in storage is 600,000 acre-ft. The basin fill may store more than 40 percent of the water; the volcanic, sedimentary and marine rocks contain the remainder.

## Operation of the Combined Flow Systems

The three subareas of the northern part of the Agua Fria area are separated by nearly impermeable basement rock that prevents

significant subsurface flow between them (pl. 1). The ground-water flow systems have minor interactions by means of surface flow; however, the subareas are nearly independent functioning systems. Ground-water development in either Lonesome Valley or Mayer subareas will affect ground-water conditions in the Black Hills subarea only by decreasing base flow in the Agua Fria River or Big Bug Creek where they flow into the Black Hills subarea. Potential recharge of less than 500 acre-ft/yr from the Agua Fria River to the Black Hills subarea may be diminished, but that quantity is small compared to an estimated 600,000 acre-feet in storage. Development in the Black Hills subarea will not affect the other two subareas.

## Ground-Water Budget

A ground-water budget is an accounting for a time period of the recharge, changes in storage, and discharge of a ground-water flow system. A budget was prepared for the 1981 water year for the part of the study area above the Agua Fria River near Mayer gaging station (pl. 3, site 7) excluding the part within the Little Chino Valley ground-water basin. The budget was prepared by estimating discharges and the change in storage in 1981; the total of these two quantities is an estimate of recharge in 1981. Recharge in 1981 was atypical owing to the effect of delayed infiltration from precipitation during 2 preceding extremely wet years. Discharge components are shown in table 1; the number of significant digits does not indicate accuracy.

The ground-water flow systems were not in equilibrium in water year 1981. Distributed recharge away from the main streams and washes occurred in the Lonesome Valley subarea and probably in the Black Hills subarea during 1981 as a result of infiltration of precipitation during the preceding 2 wet years. Water levels were rising or were constant in some wells in the vicinity of Fain Ranch and Prescott Country Club while water levels in several pumped wells probably were declining. Water-level data are inadequate to estimate the distributed recharge in the Black Hills subarea. Substantial infiltration occurred along streams and washes in 1979 and 1980 because of greater-than-average runoff; a much smaller amount of infiltration occurred in 1981. Base-flow discharges along the Agua Fria River and tributaries reflected the high infiltration of the preceding wet years and probably were the greatest since 1942; discharges and lengths of reach in which flow occurs will be less in a period of normal years. The transient hydrologic conditions and lack of water-level data prevented estimation of reasonably accurate values of change in storage and thus recharge. The quantities listed in table 1 are intended to indicate the magnitude of the components of the ground-water budget.

Discharge.--The discharge components of this budget are ground water withdrawn for irrigation, domestic, and commercial use; base flow of the Agua Fria River; and evapotranspiration from riparian areas. Consumptive use by crops includes limited surface-water diversions in the area outside Lonesome Valley. Total discharge from the

Table 1.--Ground-water budget for the study area excluding the Little Chino Valley ground-water basin for the 1981 water year

[Components of this budget are estimated and indicate the magnitude of the transient hydrologic conditions. Values are in acre-feet]

| | |
|---|---|
| Discharge: | |
| Irrigation (consumptive use by crops) | 4,400 |
| Domestic and commercial use | 1,300 |
| Evapotranspiration (riparian vegetation) | 1,100 |
| Base flow past Agua Fria River near Mayer gage (site 7, pl. 3) | 2,900 |
| Total | 9,700 |
| Change in storage: | |
| Upper Agua Fria ground-water basin | 5,000 |
| Black Hills subarea | [1]0 |
| Mayer subarea | [1]0 |
| Total | 5,000 |
| Recharge: | |
| Upper Agua Fria ground-water basin | 9,200 |
| Black Hills and Mayer subareas | 5,500 |
| Total | [2]14,700 |

[1]Probably an increase in storage in 1981, but data were not adequate to make estimates.

[2]Minimum value for recharge; data were not adequate to estimate the increase in storage in the Black Hills and Mayer subareas.

study area in 1981 is estimated to be 9,700 acre-ft; this discharge is greater than average because of a higher-than-average base flow in the Agua Fria River.

Irrigation pumpage for the study area was estimated by determining the amount of irrigated acreage from aerial photographs taken September 25, 1980, or October 15, 1977, and applying an annual consumptive-use rate of 4 acre-ft/acre. Domestic pumpage from private wells was estimated to be less than 100 acre-ft. Pumpage for the Prescott Country Club golf course was reported. Pumpage by water companies was reported or estimated on the basis of previous pumpage records. Base flow of the Agua Fria River near Mayer was estimated from adjusted streamflow hydrographs and flow-duration curves. Evaportranspiration was estimated by determining aerial coverage of vegetation and open water along streams and multiplying by an annual consumptive-use rate of 3 acre-ft/acre (Anderson, 1976).

Base flow of the Agua Fria River at Humboldt continued throughout the 1981 water year and probably was greater than that in an average year. Base flow of 1.61 $ft^3/s$ was measured on November 21, 1980, and 0.84 $ft^3/s$ on June 2, 1981 (table 2 and pl. 3, site 1) when evapotranspiration was near annual minimum and maximum values, respectively. The average of these measurements was used as an estimate of base flow for the year. Personnel of the Arizona Department of Water Resources measured 1.21 and 0.95 $ft^3/s$ at the site on August 21 and September 22, 1981, respectively. The discharge at this point during water year 1981 is estimated to be 1,000 acre-ft. About 500 acre-ft of the base flow at Humboldt reached the Black Hills subarea in sec. 22, T. 12 N., R. 2 E., and infiltrated into the bed of the Agua Fria River. The rest evaporated or was transpired. Discharge from the Mayer subarea was a few acre-feet of base flow to Big Bug Creek, which enters the Black Hills subarea above Spring Valley. About 2,900 acre-ft of ground water discharged from the Black Hills subarea in water year 1981 as base flow in the Agua Fria River (table 1 and pl. 3, site 7). Total runoff for water years 1979 and 1980 at the Agua Fria River near Mayer gaging station was the greatest for 2 consecutive years since 1941 (fig. 3). Total runoff in 1981 was below normal—35 percent of average—but the continued high base flow indicated that the infiltration of the previous 2 years had not completely drained from the ground-water system. The gaging-station record does not directly represent conditions in the Upper Agua Fria ground-water basin but is a general indicator of conditions in the Black Hills subarea.

Change in storage.--Change in storage in the Upper Agua Fria ground-water basin was estimated on the basis of changes in water levels and an assumed specific yield of the aquifer material of the major aquifer. The estimate of change in storage is subject to large error owing to the uncertainty of the average water-level change. In Lonesome Valley, data

Table 2.--Base-flow discharge measurements along the Agua Fria River and tributaries for the 1981 water year

[Remarks: QW, chemical analyses; #718, measurement number]

| Site (See plate 2) | Stream | Tributary to | Location | Latitude | Longitude | Date | Discharge, in cubic feet per second | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Agua Fria River | Gila River | Lazy River Drive, Humboldt T.13 N., R.1 E., sec. 14, NE¼SE¼SW¼ | 34°30'08" | 112°13'45" | 11-21-80 | 1.61 | QW |
| | | | | | | 06-02-81 | .84 | |
| 2 | Do. | do. | Below Humboldt T.13 N., R. 21 E., sec. 22, SE¼SE¼SE¼ | 34°29'11" | 112°14'03" | 06-02-81 | .80 | |
| 3 | Do. | do. | At (A-12-01)01cba T. 12 N., R.1 E., sec. 1, NE¼NW¼SW¼ | 34°26'57" | 112°12'48" | 11-21-80 | 1.37 | |
| | | | | | | 06-03-81 | .22 | |
| 4 | Do. | do. | At (A-12-02)17aaa T.12 N., R.2 E., sec. 17, NE¼NE¼NE¼ | 34°25'43" | 112°09'59" | 11-22-80 | .61 | |
| | | | | | | 06-03-81 | .55 | |
| 5 | Do. | do. | 3,600 ft above Arcosanti T.11 N., R.2 E., sec. 12, SW¼NW¼NE¼ | 34°21'05" | 112°06'08" | 11-22-80 | 1.23 | QW |
| | | | | | | 06-03-81 | .86 | |
| 6 | Do. | do. | 300 ft below Sycamore Creek T.11 N., R.3 E., sec. 20, NW¼NE¼NW¼ | 34°19'25" | 112°04'17" | 11-24-80 | 3.84 | |
| | | | | | | 06-04-81 | 1.23 | |
| 7 | Do. | do. | Near Mayer, (09512500) 700 ft below Big Bug Creek T.11 N., R.3 E., sec. 20, SE¼NW¼SE¼ | 34°18'55" | 112°03'48" | 11-20-80 | 5.77 | #718 |
| | | | | | | 11-25-80 | 4.93 | #719 QW |
| | | | | | | 12-11-80 | 6.65 | #720 |
| | | | | | | 06-06-81 | 2.20 | #725 |
| | | | | | | 06-01-81 | 3.77 | #724 |
| 8 | Do. | do. | 2,800 ft below Bloody Basin Road, T.10 N., R.3 E., sec. 8, SW¼NW¼SE¼ | 34°15'28" | 112°03'46" | 12-12-80 | 6.56 | QW |
| 9 | Little Ash Creek | Ash Creek | Near Dugas Road T.12 N., R.3 E, sec. 34, NE¼NE¼NW¼ | 34°22'57" | 112°01'51" | 06-04-81 | .30 | |
| 10 | Ash Creek | Agua Fria River | 3,600 ft above Agua Fria River, T.11 N., R.3 E., sec. 17, SW¼NW¼NW¼ | 34°20'10" | 112°04'35" | 11-23-80 | .98 | QW |
| 11 | Do. | do. | 4,600 ft above Agua Fria River, T.11 N., R.3 E., sec. 18, NE¼NE¼NE¼ | 34°20'33" | 112°04'37" | 06-04-81 | 1.18 | |
| 12 | Sycamore Creek | do. | 400 ft below Nelson Place Spring, T.11 N., R.5 E., sec. 21, NE¼SE¼NE¼, unsurveyed | 34°19'16" | 111°49'47" | 12-13-80 | .31 | QW |
| | | | | | | 06-05-81 | .21 | |
| 13 | Do. | do. | Dugas T.11 N., R.4 E., sec. 6, NE¼NE¼SW¼ | 34°21'38" | 111°58'43" | 12-16-80 | .71 | |
| | | | | | | 06-05-81 | .28 | |
| 14 | Little Sycamore Creek | Sycamore Creek | Dugas Road T.11 N., R.4 E., sec. 6, NE¼NE¼SW¼ | 34°21'43" | 111°58'44" | 12-16-80 | .41 | |
| | | | | | | 06-05-81 | .15 | |
| 15 | Sycamore Creek | Agua Fria River | 4,600 ft above Agua Fria River, T.11 N., R.3 E., sec. 17, NE¼NE¼SE¼ | 34°19'53" | 112°03'39" | 11-23-80 | 1.07 | |
| 16 | Do. | do. | 300 ft above Agua Fria River, T.11 N., R.3 E., sec. 20, NE¼NE¼NW¼ | 34°19'28" | 112°04'09" | 06-04-81 | .17 | QW |
| 17 | Big Bug Creek | do. | 150 ft above Agua Fria River, T.11 N., R.3 E., sec. 20, SW¼NW¼SE¼ | 34°18'54" | 112°03'58" | 11-20-80 | .56 | |
| | | | | | | 06-01-81 | .28 | |

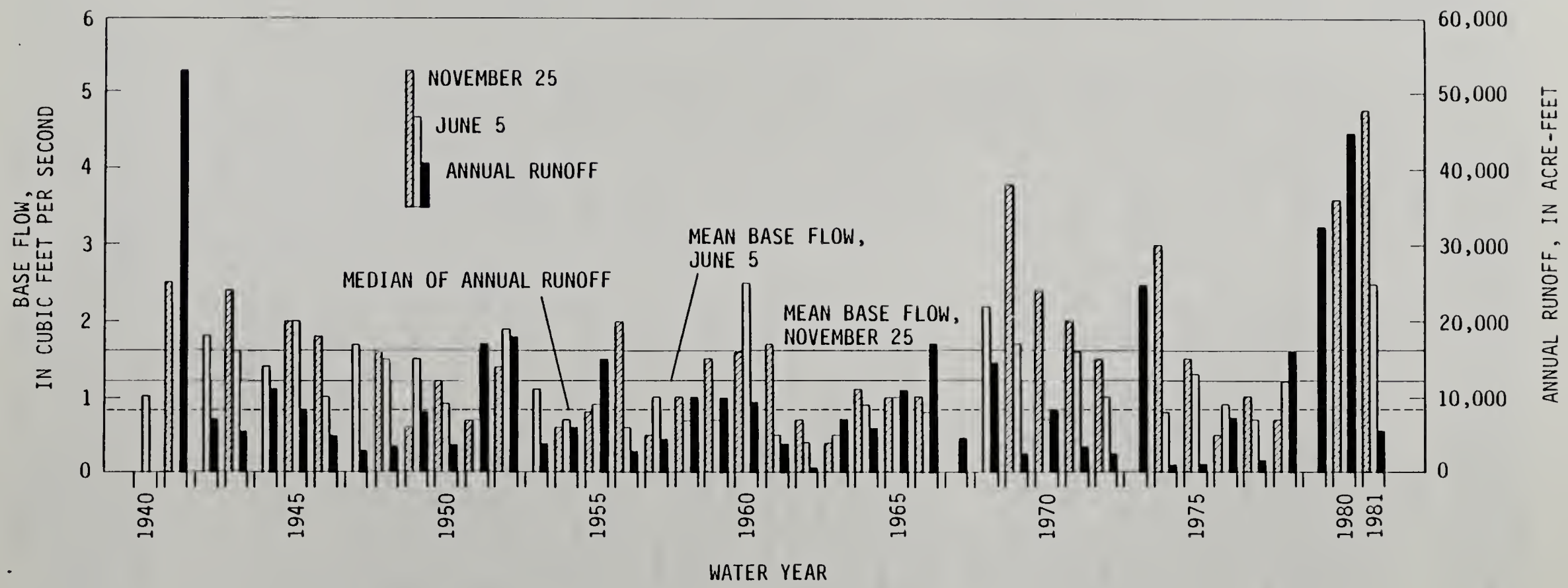


Figure 3.--Base flow for November 25 and June 5 and annual runoff, Agua Fria River near Mayer, 1941-81 water years.

indicate that water levels generally rose or were constant except for local declines in response to withdrawal in the vicinity of Fain Ranch and Prescott Country Club. The water-level rises were from 0 to 10 ft. The water level in well (A-14-01)27dbb rose at least 10.3 ft in water year 1981. The well is 2,000 ft east of the Agua Fria River and 3,000 ft east of Lynx Creek, which are the nearest sources of significant infiltration from streamflow. The nearest pumped wells are 4,000 ft away. An order-of-magnitude estimate of the gain in storage is 5,000 acre-ft assuming an average rise of about 2 ft and a specific yield of 0.12 distributed over the area of the major aquifer. The gain in storage in the Upper Agua Fria basin is not representative of average conditions.

Change in storage in the Mayer subarea was small and is assumed to be zero. Most of the recharge is consumed by pumpage and evapotranspiration; only a few acre-feet of water leaves the subarea as base flow.

Data are inadequate to determine the net change in storage in the Black Hills subarea. A net increase in storage probably occurred in 1981 but the quantity per unit area probably was less than that in Lonesome Valley. The clayey soil covering much of the subarea may cause lower than average infiltration of precipitation. A net outflow of water from storage occurred near the Agua Fria River and larger tributaries. In the large part of the subarea distant from the major streams and washes, however, recharge probably was still occurring in response to larger-than-normal precipitation and runoff in 1979 and 1980. Water pumped from wells near Big Bug Creek at Spring Valley and Cordes Junction probably was balanced by local recharge. Less than 100 acre-ft was pumped from storage near the intersection of Interstate 17 and State Route 69. The change in storage is assumed to be zero for estimation of the budget.

Recharge.--Recharge to the ground-water system occurs as infiltration of runoff in streams and washes and by infiltration of precipitation into permeable rock units. Infiltration along the streams and washes probably was less than average in 1981 because total runoff was about one-third of average. Streamflow or channel-loss data are not available to make an estimate of this infiltration.

Recharge to the ground-water system in the Upper Agua Fria ground-water basin in 1981 was equal to the total of discharge and change in storage and is estimated to be 9,200 acre-ft. Water year 1981, however, is not typical. Discharge was greater than average because of the large base-flow component, and the gain in storage was a delayed result of 2 extremely wet years. Typical recharge to the Upper Agua Fria ground-water basin may be only 2,000 or 3,000 acre-ft/yr. Recharge in the Mayer subarea was about the same as discharge and probably was less than 100 acre-ft. Recharge in the Black Hills subarea was estimated by assuming that recharge was equal to discharge because the change in storage was positive but small. Change in storage

in Mayer and Black Hills subareas was assumed to be 0 for estimation of the recharge components of this budget.

Total recharge in the study area, excluding the Little Chino Valley ground-water basin, is estimated to be 14,700 acre-ft in 1981 (table 1). This estimate is based on values of the discharge from the system and the increase in water stored in the system and probably is much greater than that in an average year. The estimate would be greater if the change in storage in Black Hills subarea could be more accurately determined.

## BASE FLOW OF STREAMS

Major streams and washes of the study area flow intermittently. Short periods of direct runoff occur in response to summer and winter rainfall and occasionally from snowmelt. After direct runoff has ended, base flow continues in some reaches of the stream channel. Base flow has two components—bank storage that drains from the sand and gravel of the banks and flood plains and long-term base flow, which is ground water that discharges into reaches of channel that are cut down into aquifers. Bank storage is water that infiltrated from the previous period of direct runoff and drains out in a few days to a few weeks. During dry years, only insignificant amounts of bank storage contribute to base flow. Long-term base flow is a result of discharge of ground water from the aquifer after months to years of movement through the aquifer. Under conditions of minimal or no ground-water development, base flow is indicative of the discharge from and therefore the recharge to the aquifer.

Base-flow reaches are discontinuous in the study area and occur principally in the major streams. Long-term base flow will occur in a reach where the channel bottom is cut down into aquifer material that drains the local system. Base flow also occurs downstream from a source area where the channel bottom is cut into nearly impermeable basement rocks. Base flow in the study area commonly is lost to evapotranspiration or infiltrates into the streambed within a few miles of its source.

Long-term base-flow variations can result from changes in ground-water discharge along source areas owing to changes in recharge from direct runoff. Several years of above-average direct runoff, such as occurred in the study area in 1979 and 1980, will recharge aquifers along stream channels and result in 1 or 2 years of above-normal base flow. Base-flow variations also can be caused by changes in consumption—crop variation or changes in area covered by water-loving plants or changes in nearby withdrawal rates. An increase or decrease in base-flow discharge will cause a corresponding lengthening or shortening of base-flow reaches.

## Seasonal Variation

Base flows along the Agua Fria River and tributaries were measured during June 1-6 and November 20 to December 11 of the 1981 water year (table 2). During those periods, direct runoff was absent and evapotranspiration was near annual maximum or minimum values. Base-flow discharges in June generally are lower and base-flow reaches are shorter than in November. The average base-flow mean daily discharge for 41 years of record at the Agua Fria River near Mayer gaging station (pl. 3, site 7) for June 5 is 1.2 $ft^3/s$ and for November 25 is 1.6 $ft^3/s$. Estimated base-flow mean daily discharges on those days at the gaging station for 1941-81 are shown in figure 3. The discharges are the sum of flow past the gage and diversion for irrigation that occurs a few hundred feet upstream. Missing values resulted from direct runoff occurring on those days or no data for diversion discharge.

## Base-Flow Availability

Base flow at the gaging station ranges from 0.1 $ft^3/s$ to about 6 $ft^3/s$. Flow equals or exceeds 0.3 $ft^3/s$ 98 percent of the time, 0.6 $ft^3/s$ 90 percent of the time, and 2.1 $ft^3/s$ 50 percent of the time (fig. 4). Forty-one years of record are available for flow past the gaging station, some of which do not account for the upstream irrigation diversion. Only 26 years of record are available for the total base flow at the site. The longer record was used to adjust the flow-duration curve for the total flow.

## Base Flows in the 1981 Water Year

Base flows measured along the Agua Fria River and tributaries during the 1981 water year probably were the greatest since 1942 and should be considered the maximum available for use by man and wildlife. The basin-fill alluvium beneath and near the channels probably was recharged to the maximum extent since 1942 because of the greater-than-average direct runoff during 1979 and 1980. The second greatest annual runoff at the gaging station occurred during 1980 and the third greatest during 1979 (fig. 3). Total runoff for 1979-80 was the highest for 2 consecutive years for the period of record. Base-flow discharge on November 25, 1980, at the Agua Fria River near Mayer gaging station was the greatest discharge in 33 record years and the June 5, 1981, base flow equaled the greatest discharge in 37 record years. Many of the reaches shown as having base flow will be dry during average to dry years. The base-flow distribution shown in Brown and others (1981) is more representative of dry years.

During the measurement period in November 1980, base flow in the Agua Fria River began 1.1 mi above Humbolt (pl. 3, site 1; table 2).

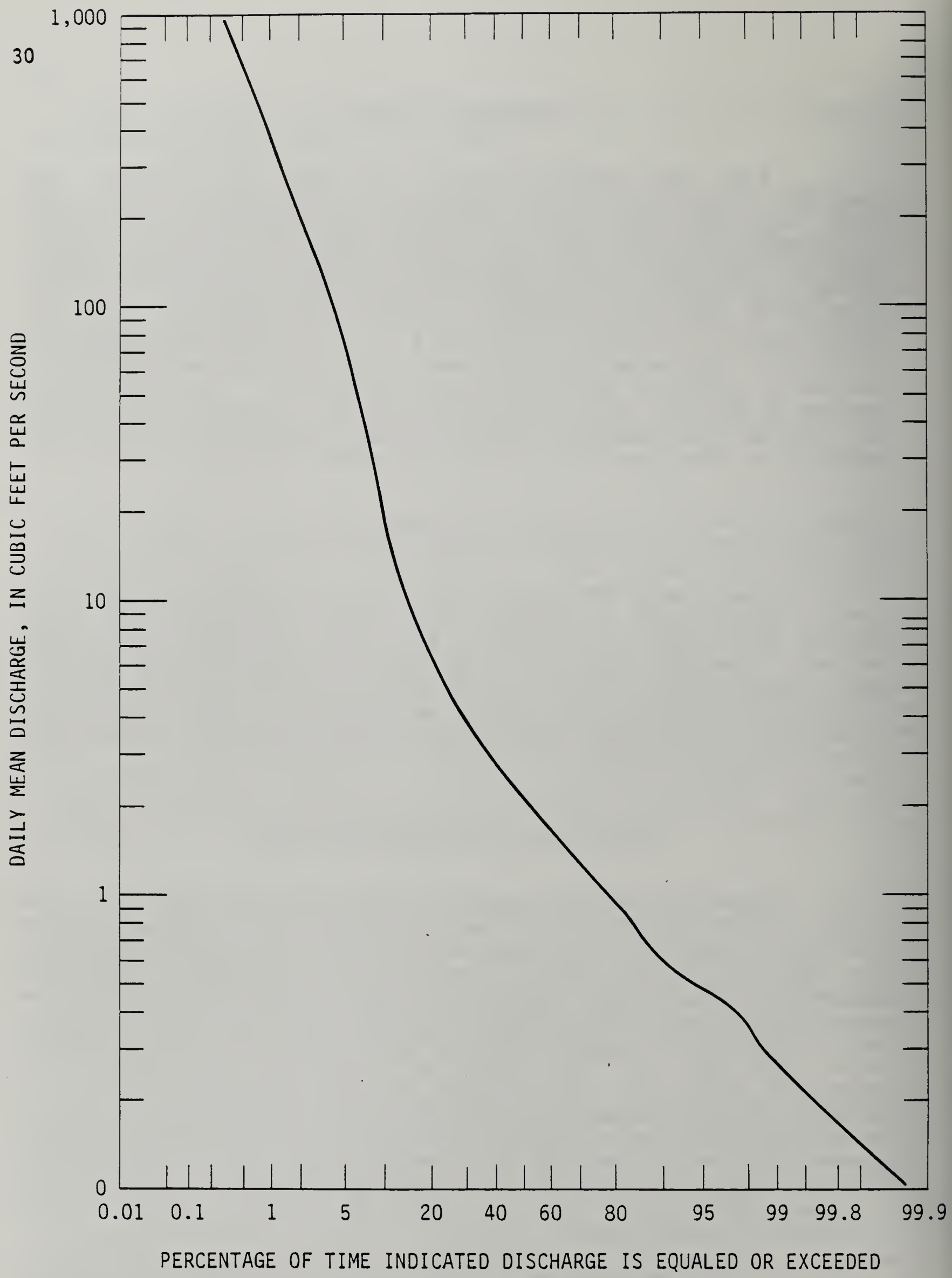


Figure 4.--Flow-duration curve, Agua Fria River near Mayer, 1941-81 water years.

Flow continued into the Black Hills subarea 3.7 mi above Interstate 17. During the June 1981 measurement period, 2.3 mi of the reach was dry. This reach is fed by ground-water discharge from the Upper Agua Fria ground-water basin. Base flow was present along a 1.2-mile reach below Interstate 17 (site 5) during both time periods. Base flow reappeared 2.2 mi above the gage (site 7) where Ash Creek and Sycamore Creek enter the Agua Fria River. This area is the main ground-water discharge point for the Black Hills subarea because the river channel is cut into low-permeability basement rock that prevents ground-water inflow below Sycamore Creek. Big Bug Creek provides the only significant addition of base flow in that reach.

Along Sycamore Creek, the November base flow began at Bee House Canyon Springs. Flow generally increased from Nelson Place Springs (site 12) to the Agua Fria River (site 15). The June base flow was less, and a few reaches in the first mile below Nelson Place Springs were dry.

The November base flow in Ash Creek began in sec. 24, T. 13 N., R. 2 E., and continued throughout its length downstream to its junction with the Agua Fria River (site 10). During the measurement period in June, Ash Creek was dry at Interstate 17 and probably along most of the channel above Interstate 17. Flow began a few hundred feet below the Interstate 17 crossing and continued to a point about 0.8 mi above Agua Fria River (site 11) where it infiltrated into the coarse sand of the channel bottom. Brown and others (1981) show perennial flow for about 4 mi below Kendall Camp where the stream is cut into basement rock. That area was not investigated during this study.

Base flow was measured at the mouth of Big Bug Creek (site 17) during both time periods. Base flow was present from the mouth to about 5 mi upstream near Cordes Junction. In June a short reach above and below Interstate 17 was wet with small pools; flow was not estimated because of disturbances in the channel for construction and diversion of flow into a pipeline that delivered water to a small pond in the southwest corner of sec. 25, T. 11 N., R. 2 E. Brown and others (1981) show perennial flow in the Bradshaw Mountains in the vicinity of sec. 6, T. 12 N., R. 1 E., where the stream is cut into basement rock and saturates a small area of basin fill.

Flow of about 0.2 $ft^3/s$ was observed in Cienega Creek in December 1980, and some flow occurred in June 1981. The stream is reported to have base flow in all but extremely dry periods.

## CHEMICAL QUALITY OF GROUND WATER AND BASE FLOW OF STREAMS

The atmosphere and rock and soil particles through which water flows are the sources of elements and compounds dissolved in ground water and base flow of streams. The atmosphere is a source of dissolved

gases of which oxygen is the most important. Carbon dioxide is primarily supplied by the soil. The soil and rock particles that form the aquifer and the overlying unsaturated zone contribute most of the dissolved solids that affect the quality of water. The particular ions in solution and their concentrations depend on the composition of the aquifer material, the availability of soluble salts, and the operation of the flow system, which determines the flow path of the water.

Near recharge areas, dissolved-solids concentrations typically are low. As the water moves through the system, it may dissolve ions from the rock material that forms the aquifer. The dissolved solids are also concentrated by evapotranspiration at places where water discharges from the system. Because of this process, water discharging from springs and as base flow commonly is of poorer quality than that stored in the main volume of the aquifer. Ion concentrations also may be changed by the adsorption of the ions on the surfaces of rock and soil particles that form the aquifer. Natural displacement of adsorbed sodium ions by calcium or magnesium ions may cause increased concentrations of sodium and decreased concentrations of the calcium and magnesium ions.

The chemical character of water is defined by the proportions of the major ions in solution. Chemical-quality diagrams can be used to compare one analysis to another and to characterize the general composition of the water sampled (pl. 3). Chemical-quality data are in table 6 in the Hydrologic Data section at the end of this report.

## Suitability for Use

The U.S. Environmental Protection Agency (1977a, b) has established national regulations and guidelines for the quality of water provided by public water systems. Primary drinking-water regulations govern contaminants that have been shown to affect human health. Secondary drinking-water regulations apply to those contaminants that affect esthetic quality. The primary regulations are enforceable either by the U.S. Environmental Protection Agency or by the States; in contrast, the secondary regulations are not Federally enforceable but are intended as guidelines for the States.

Chemical quality of ground water and base flow in the study area generally is acceptable for public supply, domestic use, stock watering, and irrigation of crops. Chemical analyses are available for 176 sites; water from 4 sites exceeded primary maximum contaminant levels for public supplies for inorganic chemicals (U.S. Environmental Protection Agency, 1976, 1977a, 1977b; Bureau of Water Quality Control, 1978). Analyses for organic and microbiological contaminants were not done.

Water from 14 sites exceeded the limits for secondary chemical contaminants; the 500 mg/L limit for total dissolved solids was exceeded at 11 sites, the 50 µg/L limit for manganese at 3 sites, and the 300 µg/L

limit for iron at 2 sites. These sites are widely scattered and do not indicate extensive areas where ground water is of poor quality.

Analyses of water from 46 sites were available for dissolved-solids concentrations. The values ranged from 132 to 748 mg/L; the median value was 360 mg/L. Dissolved-solids concentrations estimated from specific-conductance values (dissolved solids = specific conductance x 0.6) ranged from 130 to 1,800 mg/L.

Water in the study area generally is suitable for irrigation. The water has a low sodium hazard and a medium to high salinity hazard (U.S. Salinity Laboratory Staff, 1954) (fig. 5). Sodium-adsorption-ratio (SAR) values range from 0.2 to 4.1 except for one value of 8.4 for water from well (A-14-01)35ddc1. Boron concentrations range from less than 1 to 520 µg/L, with a median value of 40 µg/L, which is less than the maximum contaminant level (U.S. Environmental Protection Agency, 1977c).

## Ground-Water Subareas

### Lonesome Valley

The chemical character of ground water in storage in the major aquifer of Lonesome Valley which discharges as base flow at Humboldt (pl. 3, site 1), typically is calcium bicarbonate with sodium and magnesium concentrations generally less than half of calcium concentrations. Water from three sites in the valley has concentrations of sodium or magnesium or both that are slightly higher than calcium. This ratio may be caused by a natural displacement of sodium ions by calcium ions. This process probably is responsible for the character of water from well (A-14-01)35ddc1 in which 92 percent of the cations are sodium and potassium. The typical bicarbonate concentration is larger than the sum of the chloride and sulfate concentrations.

Total dissolved-solids concentrations range from 196 to 460 mg/L in the major aquifer in Lonesome Valley. Dissolved-solids concentations estimated from specific-conductance values range from 130 to 440 mg/L. The water generally is hard with hardness concentrations ranging from 120 to 280 mg/L as $CaCO_3$. The value of 10 mg/L for well (A-14-01)35ddc1 probably is not representative of a large volume of soft water, but soft water may occur near the center of the valley.

Dissolved-solids concentrations in water from wells and springs outside the major aquifer in the Blue Hills and Bradshaw Mountains west of Humboldt commonly exceed the 500 mg/L secondary limit. Estimated dissolved-solid concentrations in water from 13 sites range from 504 to 1,830 mg/L. The water is withdrawn mainly from the basement rock unit.

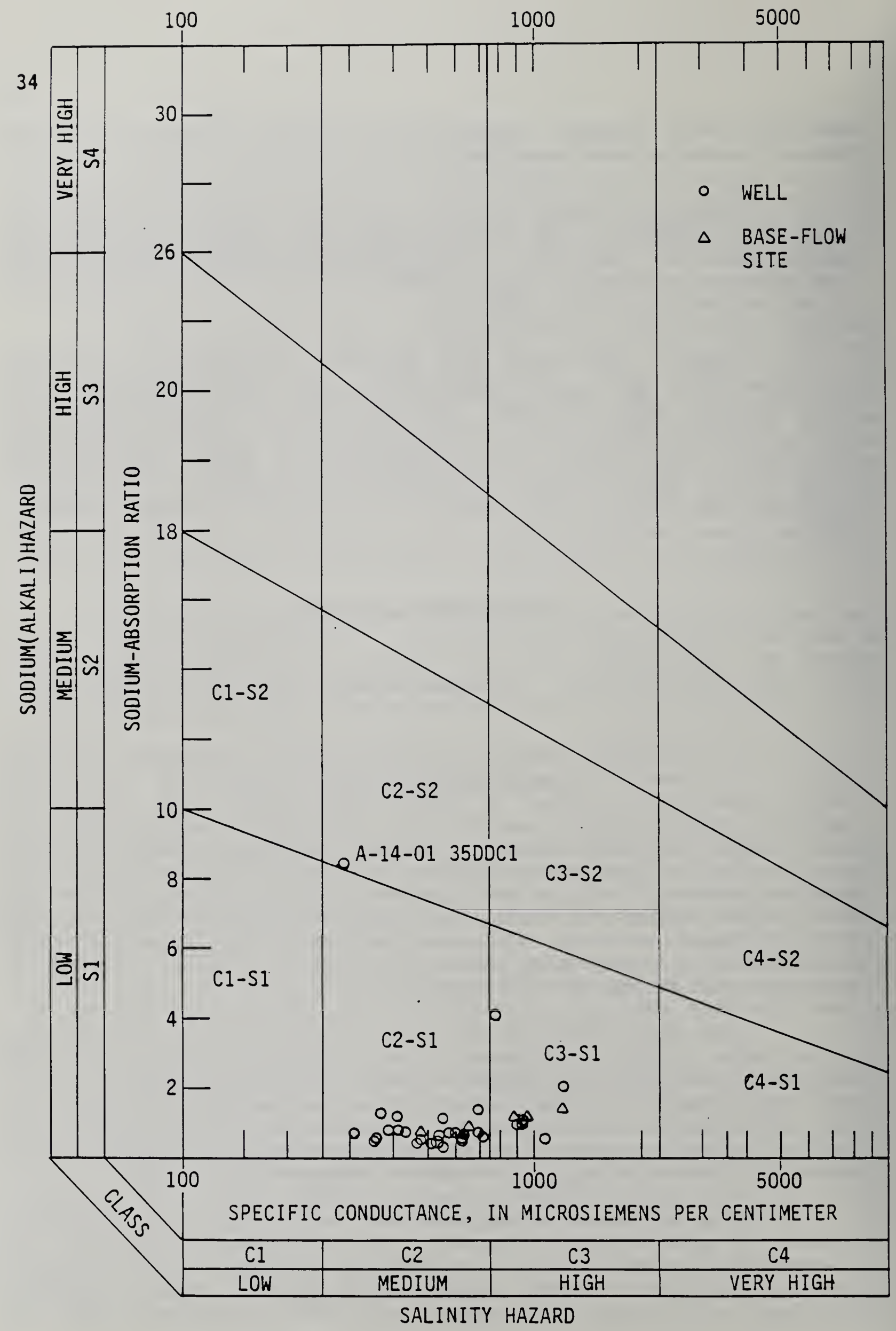


Figure 5.--Sodium and salinity hazard of ground water.

Fluoride concentrations range from 0.2 to 0.9 mg/L, and most values are between 0.3 and 0.8 mg/L. The fluoride concentration in sec. 5, T. 14 N., R. 1 W., may be more than 1 mg/L because water that contains 3.0 and 1.8 mg/L occurs upgradient in wells (B-14-01)06add and (B-14-02)01dcd, respectively.

Concentrations of arsenic and chromium in water from well (A-14-01)35ddc1 exceed the limits of 50 µg/L. The well yields a sodium bicarbonate water that is dissimilar in chemical character to most of the water sampled in Lonesome Valley. The ion-displacement process probably increased sodium concentrations and decreased calcium and magnesium in water from this well. If excessive arsenic and chromium levels are related to the process, then other nearby wells may yield water that contains excessive levels of arsenic and chromium.

Water in the basin fill in Coyote Springs ground-water basin is calcium magnesium bicarbonate in character. Dissolved-solids concentrations range from 266 to 518 mg/L. The water generally is hard, and hardness ranges from 210 to 350 mg/L as $CaCO_3$. Fluoride concentrations range from 0.2 mg/L to 0.9 mg/L. The chemical character of the water is consistent with the presence of significant amounts of limestone and dolomite in the Black Hills to the east of the basin where most of the recharge originates.

## Mayer

Ground water in the Mayer subarea is variable in quality; specific-conductance values range from 370 to 2,130 microsiemens per centimeter (µS/cm) at 25 °C. The estimated dissolved-solids concentrations range from 220 to 1,280 mg/L; the single measured value is 698 mg/L. Fluoride concentrations range from 0.2 to 0.7 mg/L. Manganese concentration in water from one well exceeds the maximum limit, however, this well may not be representative of average water quality in the area.

## Black Hills

The chemical character of ground water near Spring Valley and Cordes Junction is calcium bicarbonate. Typically, sodium and magnesium concentrations are about half of the calcium concentration, and chloride and sulfate concentrations are about one-quarter of the bicarbonate concentration. Hardness values are 234 to 290 mg/L as $CaCo_3$. Dissolved-solids concentrations range from 336 to 405 mg/L, and estimated dissolved-solids concentrations from specific-conductance values range from 150 to 370 mg/L. Fluoride concentrations range from 0.1 to 1.0 mg/L.

## Base Flow of Streams

Water samples for chemical analyses were taken during November and December 1980. Sampling sites are listed on plate 3 and table 2, and data are in table 6. During the sampling period, base flow in the Agua Fria River and its tributaries probably were the greatest since 1942. During a normal to dry year, the concentrations of dissolved solids and specific-conductance values will be larger owing to lower discharges with a larger part of the water being lost to evapotranspiration.

Dissolved-solids concentrations and specific-conductance values generally increase downstream along the Agua Fria River and Sycamore Creek except where tributary inflow of water that contains smaller concentrations dilutes the streamflow. The dissolved-solids concentration at Humboldt (site 1) is 306 mg/L and increases to 582 mg/L at site 3A, which is 5 mi downstream. Dissolved-solids concentration in the base flow at the Agua Fria River near Mayer gaging station is smaller than that at site 5 because of dilution by tributary inflow from Ash Creek (site 10) and Sycamore Creek (site 16). Specific conductance along the Agua Fria River ranged from 486 µS/cm at 25 °C at Humboldt (site 1) to 1,211 µS/cm at site 5. Below site 5, values ranged from 974 to 872 µS/cm.

Base flow in the Agua Fria River is calcium bicarbonate in character. Sodium and magnesium are about equal in concentration and the total is slightly larger than the calcium concentration. The concentration of chloride is slightly lower than sulfate with the sum exceeding the bicarbonate value. The calcium bicarbonate water leaving Lonesome Valley at Humboldt probably dissolves gypsum and halite along the channel in the reach downstream to site 3A. Base flow at site 5 is calcium bicarbonate in character and is a mixture of Agua Fria River water and ground water probably originating from Big Bug Creek. Evapotranspiration along Agua Fria River probably increased the dissolved-solids concentration. Base flow at the gaging station (site 7) is calcium magnesium bicarbonate water that shows an increase of magnesium and bicarbonate and a decrease of sodium and sulfate because of tributary inflow from Ash and Sycamore Creeks. Chemical character of base flow in Ash and Sycamore Creeks is calcium magnesium bicarbonate.

Base flow of the Agua Fria River at and below Humboldt was analyzed for heavy metals and cyanide. No significant concentrations were found. Water from Sycamore Creek below Nelson Place Springs (site 12) contained 63 µg/L of lead, but lead was not detected at site 16. Lead was also below the detection limit at sites 1 and 3A on the Agua Fria River. The concentration seems anomalous, and the source of the lead is unknown.

Chemical character of ground water and base flow generally is similar where exchange between the stream and the aquifer is occurring. The character for water from well (A-12-02)08dbd and site 3A indicates

that the alluvium in that area is recharged from flow in the Agua Fria River. The character of water from well (A-12-03)08bdd is similar to base flow at site 10 on Ash Creek.

## EFFECTS OF WATER-RESOURCES DEVELOPMENT

The water resources of the northern part of the Agua Fria area are limited owing to the semiarid climate. Ground water is and has been the source for public supplies and most irrigation and domestic supplies. Past withdrawals have caused water-level declines in three areas. Near-future increases in water use will need to be met by increased ground-water withdrawals because alternate sources are not currently available. A large increase in withdrawals will cause additional water-level declines.

Contamination of ground water stored in the aquifers of the study area would threaten the potability of water supplies and could create a health hazard. Knowledge of contamination potential can help local residents and owners prevent ground-water contamination.

### Water-Level Declines

Hydraulic head in an area of about 5 $mi^2$ near Prescott County Club and Fain Ranch has declined as much as 50 ft in response to pumping for irrigation and public supply (pl. 2). The area of decline was estimated from measured and reported water levels in six wells and the shape of potentiometric contours. Most of the decline has occurred since 1967 although pumping at Fain Ranch began in 1936. Fine-grained material occurs in the upper layers of the aquifer in the area, and ground water in deeper layers may occur under confined conditions. Before significant pumping began, there probably was little hydraulic-head variation with depth. Hydraulic heads in 1981 were lower in some deeper wells than in nearby shallow ones. Continued pumping in the vicinity will cause additional lowering of hydraulic heads until the cone of depression is large enough to induce sufficient recharge of water through the fine-grained layers to stabilize heads. If the rate of pumping is greater than the average recharge, the hydraulic heads will continue to decline.

Water levels have declined in the vicinity of Prescott Valley in the two active public-supply wells and in a few nearby wells. The water level in well (B-14-01)15aba has declined 66 ft since 1972. Well (B-14-01)10acd, which is pumped for a public water supply, has declined about 18 ft since 1972. The water level in well (B-14-01)14acc has declined 10 ft since 1978. The altitude of water levels in wells varies in the area because hydraulic heads are different above and below lava flows in the subsurface. The flows can retard or prevent the vertical movement of water in response to recharge or discharge. Water levels in wells

(B-14-01)11daa and (B-14-01)14acc represent hydraulic heads above lava flows, but the water level in well (B-14-01)10acd represents hydraulic heads unaffected by lava flows. During the drilling of well (B-14-01)15aba, water was first encountered above the upper lava flow. Water levels in the well in 1971 and 1972 represented combined hydraulic heads. The hydraulic head is now below the lava flows, and water originating above the upper lava flow cascades down the hole to the potentiometric surface, which is 526 ft below land surface.

No significant water-level changes have occurred in the Mayer subarea. No large cones of depression have developed from past withdrawals in Black Hills subarea. Minor local declines of a few feet may have slightly changed the shape of the potentiometric surface near the intersection of Interstate 17 and State Route 69 at Cordes Junction.

## Potential Ground-Water Contamination

Ground-water contamination from man's activities can be minimized by identification of potential contaminant sources; delineation of areas where contaminants may readily enter aquifers; and joint action by managers, developers, and landowners to control use and disposal of potential contaminants. Contaminants can enter the aquifer at any location; however, it will take longer for the contaminants to penetrate to the saturated zone where depth to water is great or where the unsaturated zone is fine grained and the vertical hydraulic conductivity is low. Common activities that may produce contaminants include agriculture, solid-waste disposal, liquid-waste disposal, wastewater treatment and effluent disposal, and transport of substances by people or natural processes. Agricultural activities apply fertilizers, herbicides, and pesticides; generate solid and liquid waste; cultivate crops; and irrigate the land. Precipitation and irrigation water may dissolve contaminants and infiltrate directly to the aquifer or runoff from the source area and infiltrate through the channel bottoms and flood plains of washes and streams. Substances dissolved from solid and liquid waste and effluent from wastewater treatment may infiltrate into the aquifer. Spills from vehicles or pipelines and accidental transport of substances by winds and floods also may contaminate aquifers.

In Lonesome Valley, contaminants could most easily enter the aquifer where infiltration of precipitation and direct runoff are concentrated along the channel bottoms, flood plains, and terraces of Lynx Creek, Agua Fria River, and larger canyons and washes. The next most easily contaminated areas are low areas near the Agua Fria River that are covered with basin-fill alluvium.

In the Mayer subarea, contaminants could most easily enter the aquifer along the channel, flood plain, and nearby low areas of Big Bug Creek that are mainly underlain by basin fill. The water table is shallow in the area, and contaminants could move downward rapidly into the aquifer.

In the Black Hills subarea, contaminants could most easily enter the aquifer along the channel, flood plains, and terraces of Agua Fria River, Big Bug, Sycamore, and Ash Creeks, and the larger washes and canyons. Most of these areas are underlain by basin fill. The next most easily contaminated area is along the west side of the subarea where basin fill crops out at the surface and precipitation can readily infiltrate into the subsurface. An area underlain by volcanic and sedimentary rocks from Cordes Junction to the Agua Fria River is subject to contamination because the volcanic rocks are fractured and may allow precipitation to move rapidly down into the aquifer.

## Present and Future Develpment

In the Lonesome Valley subarea, the withdrawal, consumption, and outflow of about 4,700 acre-ft of ground water in 1981 was small compared to more than 800,000 acre-ft in storage. Effects of development through 1981 have been slight. Withdrawals in 1981 were less than recharge although local water-level declines have occurred in two places. Ground-water resources of Lonesome Valley are moderately developed at Prescott Valley and in the area from Fain Ranch south to Humboldt. The northeastern part of Lonesome Valley and Coyote Springs ground-water basin have little or no development. Wells have not been drilled in an area of about 25 $mi^2$ where Little Chino Valley ground-water basin and Upper Agua Fria ground-water basin join, and subsurface conditions are unknown.

Lonesome Valley contains the largest volume of water in storage in the study area and is the most favorable for exploration and development of new public or commercial water supplies. A major increase in withdrawal would be from water in storage, and water levels would decline. An increase in withdrawal in the Dewey-Humboldt area will reduce the base flow in the Agua Fria River at Humboldt.

The ground-water resources of the Mayer subarea are limited owing to the small volume of the aquifer. A few thousand acre-feet of water are in storage. The major aquifer is unfavorable for development of substantial new public or commercial supplies.

Significant development of ground water in Black Hills subarea has occurred at Spring Valley, Cordes Junction, Orme Ranch, and in secs. 22 and 27, T. 12 N., R. 2 E., however, much of the subarea is undeveloped. The most favorable place to search for new public or commercial water supplies is along the western side of the subarea and is indicated on plate 2 by a potential yield pattern of 50 to 1,000 gal/min. The least favorable area to search is in the Black Hills on mesas between major canyons or ridge tops near basement-rock outcrops.

## Future Data Needs

In order to make a quantitative analysis of the ground-water flow system in the Lonesome Valley subarea and evaluate the effects of present and future development, it is essential to determine the nature of the hydraulic connection between the Little Chino Valley and the Upper Agua Fria ground-water basins. The area where the two flow systems join includes about 25 $mi^2$. Wells were not developed in this area at the time of this study. Part of the current land development is in this area and most of the future population expansion probably will occur here. A major increase in ground-water withdrawal could cause water-level declines in one or both ground-water basins depending on the nature of their hydraulic connection and the volume of ground water in storage. Additional quantitative data required include:

1. Extent, thickness, and hydraulic parameters of the aquifer in the main part of Lonesome Valley.
2. Annual runoff and channel losses in Lynx Creek, Coyote Wash, Yaeger Canyon, Clipper Wash, the Agua Fria River, and other washes that are a major source of recharge to the system.
3. Changes in the shape of the potentiometric surface and in water levels with time.
4. Distribution and volume of ground-water withdrawal.
5. Estimates of return flow from irrigation.

Infiltration from direct runoff in Big Bug Creek provides much of the recharge near Mayer, Spring Valley, and Cordes Junction. A significant volume of ground water is in storage in the vicinity of Spring Valley and Cordes Junction but storage is limited near Mayer. In order to make a quantitative analysis of the ground-water flow system, determine the volume of ground water in storage, and estimate effects of future development, at least the following data will be required:

1. Extent, thickness, and hydraulic parameters of the aquifers from above Mayer to the Agua Fria River.
2. Annual runoff and channel losses in Big Bug Creek from Poland Junction to the mouth and in the Agua Fria River from sec. 21, T. 12 N., R. 2 E., to the Agua Fria River near Mayer gaging station.
3. Changes in the shape of the potentiometric surface and in water levels with time.
4. Distribution and volume of ground-water withdrawal.

# SUMMARY

At least 1,400,000 acre-feet of ground water is in storage in the major aquifers in the northern part of the Agua Fria area. Ground water is the source for all public water supplies and most irrigation and private supplies in the 700-square-mile area. Base flow and direct runoff in the Agua Fria River and its tributaries are reserved for local and downstream users who have existing water rights. The increasing demand for water caused by the rapid population growth and development will need to be met by increased ground-water withdrawals. Alternate sources of water are not currently available.

The study area is divided into three subareas—Lonesome Valley, Mayer, and Black Hills—that are separated by nearly impermeable basement rocks that prevent significant ground-water flow between them. The geologic formations of the area are combined into hydrologic rock units that have similar ground-water storage and transmissive properties. They include basement, marine, sedimentary, volcanic, and basin fill. Basement rocks are nearly impermeable and serve to separate the ground-water systems. One or more of the remaining units form the aquifer in the subareas. Basin-fill and sedimentary rocks are the most permeable units and may yield as much as 2,000 gallons per minute of water to wells where saturated.

The subareas are nearly independent ground-water systems but have minor interactions by means of surface flow. Ground-water development in either Lonesome Valley or Mayer will affect ground-water conditions in the Black Hills subarea only by decreasing potential recharge from base flow in the Agua Fria River by less than 500 acre-ft/yr or in Big Bug Creek by a few acre-feet per year. Development in the Black Hills subarea will not affect the other two subareas.

Effects of ground-water development through 1981 in the Lonesome Valley subarea have been slight. Local hydraulic-head declines of as much as 50 feet have occurred near Fain Ranch and Prescott Country Club and declines of a few tens of feet have occurred in the Prescott Valley area. The subarea contains about 800,000 acre-feet of water in storage and is the most favorable for development of new water supplies. A major increase in withdrawal would result in the removal of water from storage, water-level declines, and a decrease in base flow in the Agua Fria River at Humboldt. The ground-water resources of the Mayer subarea are small owing to the limited volume of the aquifer; a few thousand acre-feet of water are in storage. Most of the Black Hills subarea has had little development; moderate ground-water development has occurred at Spring Valley and Cordes Junction. An estimate of water in storage is 600,000 acre-feet; aquifer volume is poorly known. The most favorable area for development of new water supplies in the Black Hills subarea is along the west side where basin fill crops out.

The source of most recharge to the ground-water flow systems is infiltration of direct runoff through the channel bottoms and flood plains of the major streams and washes; some recharge is from infiltration of precipitation on the rock units that form the aquifers. Ground water moves from higher recharge areas toward lower discharge areas and is discharged as pumpage, evapotranspiration, or base flow in the Agua Fria River and its tributaries. In the Little Chino Valley ground-water basin, some ground water moves northwestward and leaves the study area as underflow.

The ground-water flow systems were not in equilibrium in water year 1981. Substantial infiltration occurred along streams and washes in 1979 and 1980 because of greater-than-average runoff; a much smaller amount of infiltration occurred in 1981. Distributed recharge away from the main streams and washes occurred in the Lonesome Valley subarea and probably in the Black Hills subarea during 1981 as a result of infiltration during the preceding 2 wet years.

A ground-water budget for the 1981 water year included a discharge of 9,700 acre-feet. About 4,400 acre-feet was used for irrigation, 1,300 acre-feet was used for domestic and commercial purposes, 1,100 acre-feet was consumed by evapotranspiration from riparian areas, and 2,900 acre-feet was base flow. Recharge of 14,700 acre-ft is the sum of discharge and change in storage. This quantity is a minimum value because data are not available to estimate the gain in storage in the Black Hills subarea. The gain in storage was assumed to be zero in the Mayer and Black Hills subarea. The gain in storage was 5,000 acre-ft in the upper Agua Fria ground-water basin.

Base flows along the Agua Fria River and its tributaries during the 1981 water year probably were the greatest since 1942 and the maximum available for use by man and wildlife. At the Agua Fria River near Mayer gaging station, base flow from ground-water discharge ranges from 0.1 to about 6 cubic feet per second.

The chemical quality of the ground water and base flow of the Agua Fria River and its tributaries in the study area generally is acceptable for public supply, domestic use, livestock, and irrigation of crops. Water from 4 of 176 sites failed to meet Arizona and U.S. Environmental Protection Agency primary water-quality standards for public supply. The general chemical character of ground water in the major aquifers is calcium bicarbonate. Total dissolved solids ranged from about 132 to 748 milligrams per liter; the median value was 360 milligrams per liter. Fluoride concentrations ranged from 0.1 to 1.0 milligrams per liter.

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# GLOSSARY

Hydrologic terms used in the report are defined below. The definitions were adapted from Baldwin and McGuinness (1963), Langbein and Iseri (1960), Lohman and others (1972), and U.S. Water Resources Council (1980).

Aquifer — A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Artesian aquifer — See confined aquifer.

Base flow — Ground water that has been discharged into a stream channel as spring or seepage water.

Confined aquifer — An aquifer that lies beneath less permeable material and in which ground water is confined under pressure significantly greater than atmospheric. Static water levels in wells that penetrate a confined aquifer are higher than the top of the aquifer. Synonym: artesian aquifer. See also unconfined aquifer.

Consumptive use — The quantity of water absorbed by crops and transpired or used directly in the building of plant tissue together with that evaporated from the cropped area.

Contaminant — Any physical, chemical, biological, or radiological substance or matter in water. U.S. Environmental Protection Agency drinking-water regulations express limits as "maximum contaminant levels."

Direct runoff — Water that enters stream channels promptly after rainfall or snowmelt.

Discharge of ground water — The processes by which water leaves an aquifer.

Evapotranspiration — Water withdrawn from a land area by evaporation from water surfaces and moist soil and by plant transpiration.

Ground-water basin—A depression of the earth's surface that is partly filled with an aquifer. The rock forming the bottom and sides of the depression is less permeable than the rock forming the aquifer.

Ground-water divide — A ridge in the water table or other potentiometric surface from which ground water moves away in both directions.

Hydraulic conductivity — The volume of water that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. Hydraulic conductivity describes the ability of the aquifer material to transmit water and may have substantially different values for horizontal and vertical flow through the same material.

Hydraulic gradient — The change in head per unit of distance in a given direction.

Hydraulic head — The height above a standard datum of the surface of a column of water that can be supported by the static pressure at a given point in an aquifer. In this report, datum used is National Geodetic Vertical Datum of 1929. See potentiometric surface.

Intermittent stream — A stream that flows only at certain times of the year when it receives water from springs or from some surface source, such as melting snow in mountainous areas. Synonym: seasonal.

National Geodetic Vertical Datum of 1929 (NGVD of 1929) — A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. Referred to as sea level in this report.

Potentiometric surface — An imaginary surface representing the static head of ground water, of which the water table is one type. The potentiometric surface for a confined aquifer is the level at which water would stand in wells that tap the aquifer.

Perched ground water — Unconfined ground water separated from an underlying body of ground water by an unsaturated zone and held up by material with a low hydraulic conductivity.

Perennial stream — A stream that flows continuously.

Recharge — The processes of addition of water to the zone of saturated permeable material.

Sorting — A measure of the range in size of particles forming a sediment. Well sorted sediments contain particles of near uniform size; poorly sorted sediments contain many sizes of particles, such as various combinations of clay, silt, sand, pebbles, cobbles, and boulders.

Specific capacity — The rate of discharge of water from the well divided by the drawdown of the water level within the well.

Specific yield — The ratio of the volume of water which a unit volume of aquifer will yield by gravity drainage to its own volume.

Storage — Water naturally or artificially impounded in an aquifer.

Transmissivity — The volume of water that will move in unit time through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity describes the ability of the entire thickness of an aquifer to transmit water and is the product of hydraulic conductivity and saturated thickness.

Unconfined aquifer — An aquifer in which the upper surface of the zone of saturation forms a water table under atmospheric pressure. Synonym: water-table aquifer. See also confined aquifer.

Water budget — An accounting of the recharge to, discharge from, and storage changes in an aquifer for a given time period.

Water table — The surface in an unconfined aquifer at which pressure is atmospheric and below which the rocks are saturated with water. The water table is the level at which water stands in wells that penetrate the uppermost part of an unconfined aquifer. See potentiometric surface.

Water-table aquifer — See unconfined aquifer.

# HYDROLOGIC DATA

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area

Local number: See figure 2 for description of well-numbering and location system.

Altitude: In feet above sea level, determined from U.S. Geological Survey topographic maps or engineer's level lines.

Water level: In feet below land surface.

Method of measurement: S, steel tape; V, calibrated electric tape; T, electric tape; R, reported.

Site status: R, recently pumped; S, nearby pumping; P, pumping; X, surface-water effect.

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-10-02 17DBA | 2925.00 | 45.20 | S | 08/22/78 | --- |
| A-10-02 17DDA | 2900.00 | 6.30 | S | 08/22/78 | --- |
| A-10-03 08ADD | 3250.00 | 14.59 | S | 05/18/78 | --- |
| A-10-03 08DAA | 3250.00 | 15.05 | S | 05/18/78 | --- |
| A-10-04 14CCD | 4370.00 | 7.46 | S | 08/21/78 | --- |
| A-11-02 02ABB1 | 3711.00 | 97.00 | S | 06/09/77 | --- |
| A-11-02 02ABB2 | 3715.00 | 50.00 | S | 06/09/77 | --- |
| | | 42.20 | S | 10/18/78 | --- |
| A-11-02 03BCC | 4060.00 | 266.70 | S | 11/13/81 | --- |
| A-11-02 06ABA | 4060.00 | 15.70 | S | 06/10/77 | --- |
| A-11-02 09BCC | 3950.00 | 31.31 | S | 02/13/82 | --- |
| A-11-02 09CCB | 3925.00 | 25.20 | --- | 06/09/77 | --- |
| | | 21.40 | S | 02/13/82 | --- |
| A-11-02 09CCC | 3940.00 | 85.50 | S | 06/09/77 | --- |
| | | 66.58 | S | 02/13/82 | R |
| A-11-02 09CCD | 3920.00 | 43.27 | S | 02/13/82 | --- |
| A-11-02 09DBD | 3970.00 | 105.10 | S | 02/13/82 | --- |
| A-11-02 09DDD | 3885.00 | 19.57 | S | 02/13/82 | --- |
| A-11-02 11CCA | 3820.00 | 43.10 | --- | 06/09/77 | --- |
| A-11-02 12BDA | 3620.00 | 24.90 | --- | 05/23/77 | --- |
| A-11-02 12DDA | 3580.00 | 36.20 | S | 05/24/77 | --- |
| A-11-02 14BDD | 3830.00 | 300.50 | V | 05/18/77 | P |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area—Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-11-02 14CAD | 3805.00 | 68.50 | S | 05/18/77 | --- |
| A-11-02 14CBB1 | 3805.00 | 79.50 | S | 06/09/77 | S |
| A-11-02 14CBB2 | 3800.00 | 64.20 | S | 06/10/77 | P |
| A-11-02 14CCA | 3810.00 | 66.65 | S | 05/25/77 | --- |
| A-11-02 14CCD1 | 3760.00 | 16.60 | S | 05/25/77 | --- |
| A-11-02 14CCD2 | 3790.00 | 18.20 | S | 05/25/77 | --- |
| A-11-02 14DAC | 3760.00 | 54.70 | S | 05/24/77 | --- |
| A-11-02 14DAD | 3745.00 | 56.90 | S | 05/24/77 | --- |
| A-11-02 14DCD2 | 3765.00 | 124.00 | --- | 05/18/77 | --- |
| A-11-02 16BBA | 3930.00 | 50.24 | S | 02/13/82 | --- |
| A-11-02 23ABA | 3770.00 | 97.00 | S | 02/10/82 | --- |
| A-11-02 23ABB1 | 3780.00 | 85.86 | S | 02/12/82 | --- |
| A-11-02 24BBB | 3730.00 | 60.11 | S | 08/23/78 | --- |
| A-11-02 24CAD | 3690.00 | 58.90 | --- | 05/18/77 | --- |
| | | 80.85 | S | 02/12/82 | --- |
| A-11-02 24DDB | 3635.00 | 58.35 | S | 02/10/82 | --- |
| A-11-02 25AAB | 3640.00 | 57.60 | S | 02/12/82 | --- |
| A-11-02 25ACD | 3685.00 | 105.50 | --- | 05/18/77 | --- |
| | | 54.60 | S | 02/12/82 | --- |
| A-11-02 25BCB | 3678.00 | 21.00 | S | 02/12/82 | --- |
| A-11-02 25BDD | 3700.00 | 123.00 | --- | 05/18/77 | --- |
| | | 98.92 | S | 02/12/82 | R |
| A-11-02 29DAA | 3770.00 | 7.01 | S | 10/20/78 | --- |
| A-11-03 17CCC | 3540.00 | 17.50 | --- | 05/23/77 | --- |
| A-11-03 18ADA | 3555.00 | 21.90 | S | 05/23/77 | --- |
| A-11-03 18DBA | 3560.00 | 26.40 | --- | 05/23/77 | --- |
| A-11-03 18DDB | 3560.00 | 18.90 | S | 05/23/77 | --- |
| A-11-04 01CBB | 4713.00 | 9.60 | S | 10/24/80 | --- |
| A-12-01 02DAA1 | 4120.00 | 24.05 | S | 10/19/78 | --- |
| A-12-01 02DAA2 | 4120.00 | 19.34 | --- | 10/19/78 | --- |
| A-12-01 04BBC3 | 4918.00 | 188.80 | --- | 08/03/77 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area--Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-12-01 04BBC4 | 4920.00 | 186.30 | --- | 08/03/77 | --- |
| A-12-01 04BBC5 | 4920.00 | 66.20 | --- | 08/03/77 | --- |
| A-12-01 04BDA | 4890.00 | 109.90 | --- | 08/03/77 | --- |
| A-12-01 04CAA1 | 4850.00 | 57.60 | --- | 08/03/77 | --- |
| A-12-01 05CAA1 | 4830.00 | 8.38 | S | 10/17/78 | --- |
| A-12-01 05CAB | 4840.00 | 20.60 | S | 10/17/78 | --- |
| A-12-01 09CCB1 | 4640.00 | 45.70 | S | 07/23/77 | --- |
| A-12-01 09CCB2 | 4640.00 | 46.90 | S | 07/23/77 | --- |
| A-12-01 09DCC2 | 4620.00 | 47.50 | --- | 08/03/77 | --- |
| A-12-01 15CDB | 4550.00 | 43.10 | --- | 08/03/77 | --- |
| A-12-01 22BBB1 | 4470.00 | 22.40 | T | 10/04/78 | --- |
| A-12-01 22BBC | 4470.00 | 18.25 | S | 10/04/78 | --- |
| A-12-01 22BCA | 4445.00 | 17.02 | S | 10/04/78 | --- |
| A-12-01 22BCD | 4440.00 | 14.02 | S | 10/04/78 | --- |
| A-12-01 22CAB | 4410.00 | 12.63 | S | 10/04/78 | --- |
| A-12-01 22CDA | 4410.00 | 13.80 | V | 10/03/78 | --- |
| A-12-01 22DDD | 4370.00 | 22.44 | S | 10/04/78 | --- |
| A-12-01 24CDC | 4408.00 | 80.50 | V | 10/19/78 | P |
| | | 67.60 | --- | 10/14/71 | --- |
| A-12-01 26BAA1 | 4360.00 | 39.10 | --- | 07/23/77 | --- |
| A-12-01 26BAB | 4375.00 | 52.80 | --- | 10/03/78 | R |
| A-12-01 26BBB | 4390.00 | 20.70 | V | 10/03/78 | --- |
| A-12-01 26DAB | 4260.00 | 26.70 | --- | 10/20/78 | --- |
| A-12-01 27DBA1 | 4475.00 | 20.37 | S | 10/03/78 | --- |
| A-12-01 27DBA2 | 4475.00 | 25.00 | S | 10/03/78 | --- |
| A-12-01 29DAC | 4900.00 | 46.50 | V | 10/05/78 | P |
| A-12-01 31BCC | 5300.00 | 16.40 | --- | 10/05/78 | P |
| A-12-01 33AAD | 4645.00 | 88.40 | V | 10/05/78 | --- |
| A-12-01 33ADA | 4640.00 | 90.00 | --- | 10/05/78 | R |
| A-12-01 33ADD | 4635.00 | 84.40 | --- | 10/05/78 | --- |
| A-12-01 34ACC | 4535.00 | 30.89 | --- | 10/05/78 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area—Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-12-01 34DAC1 | 4480.00 | 63.60 | --- | 10/05/78 | --- |
| A-12-01 34DBB | 4525.00 | 24.40 | --- | 10/05/78 | --- |
| A-12-01 36ABD | 4210.00 | 25.10 | --- | 10/04/78 | --- |
| A-12-02 01DAC | 4070.00 | 130.10 | --- | 08/31/78 | --- |
| | | 125.10 | --- | 02/01/81 | --- |
| | | 128.60 | S | 12/22/81 | --- |
| A-12-02 04AAD | 4210.00 | 27.30 | S | 10/18/78 | --- |
| A-12-02 08DBA | 3965.00 | 35.90 | V | 10/18/78 | --- |
| A-12-02 22BCD | 3812.00 | 60.10 | V | 10/19/78 | R |
| A-12-02 22CDD | 3780.00 | 26.36 | S | 10/19/78 | --- |
| A-12-02 23BAA | 3870.00 | 40.42 | S | 09/05/78 | --- |
| | | 37.90 | | 02/06/81 | --- |
| | | 40.76 | S | 12/22/81 | --- |
| A-12-02 27ACB | 3770.00 | 5.37 | S | 03/20/79 | --- |
| A-12-02 27BDA1 | 3766.00 | 19.80 | V | 10/18/78 | --- |
| A-12-02 27BDA2 | 3766.00 | 20.76 | S | 10/18/78 | --- |
| A-12-02 27DDB | 3750.00 | 19.00 | V | 10/18/78 | --- |
| A-12-02 28CBD | 4000.00 | 85.70 | V | 10/19/78 | --- |
| A-12-02 29ACD | 4100.00 | 108.70 | V | 10/19/78 | R |
| A-12-02 35DCC1 | 3700.00 | 71.00 | R | 01/01/62 | --- |
| A-12-03 10BAB | 4110.00 | 79.02 | S | 09/05/78 | --- |
| A-12-03 11BBC | 4130.00 | 41.98 | S | 08/31/78 | --- |
| A-12-03 12CDD | 4230.00 | 136.59 | S | 12/15/80 | --- |
| A-12-03 22BBC | 3955.00 | 72.75 | S | 08/31/78 | P |
| A-12-04 18AAA | 4260.00 | 153.15 | S | 12/15/80 | --- |
| A-13-01 01AAC | 4745.00 | 217.80 | S | 09/22/81 | --- |
| A-13-01 01ACC | 4705.00 | 174.34 | S | 08/22/78 | --- |
| | | 173.50 | S | 09/22/81 | --- |
| A-13-01 01BAA | 4680.00 | 149.57 | S | 09/22/81 | --- |
| | | 150.17 | S | 02/25/82 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area--Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-13-01 01CBB | 4620.00 | 106.19 | S | 09/25/81 | --- |
| A-13-01 01CCD | 4640.00 | 123.94 | S | 08/22/78 | --- |
| A-13-01 01DBB | 4690.00 | 169.59 | S | 09/22/81 | --- |
| A-13-01 01DCA | 4740.00 | 212.69 | S | 09/22/81 | --- |
| | | 208.80 | V | 02/25/82 | --- |
| A-13-01 02CAC | 4603.00 | 85.10 | S | 04/18/73 | --- |
| | | 89.50 | S | 01/07/76 | --- |
| | | 88.00 | S | 01/18/77 | --- |
| | | 89.05 | S | 03/14/78 | --- |
| | | 89.40 | S | 09/14/78 | --- |
| | | 86.80 | --- | 03/20/79 | P |
| | | 82.30 | --- | 04/01/80 | --- |
| | | 93.40 | --- | 02/06/81 | --- |
| | | 88.62 | S | 09/22/81 | --- |
| | | 87.30 | V | 02/24/82 | --- |
| A-13-01 02CCD | 4560.00 | 40.19 | S | 09/22/81 | --- |
| A-13-01 02DCA | 4585.00 | 79.45 | S | 10/04/78 | --- |
| | | 75.20 | V | 02/22/82 | --- |
| A-13-01 03ABB | 4602.00 | 38.70 | S | 09/20/78 | --- |
| | | 38.44 | S | 09/25/81 | --- |
| A-13-01 03ADA | 4580.00 | 33.90 | S | 09/25/81 | --- |
| A-13-01 03BCA | 4640.00 | 64.40 | S | 09/12/78 | --- |
| | | 66.02 | S | 09/25/81 | --- |
| A-13-01 03DBC2 | 4610.00 | 55.00 | R | 09/12/78 | --- |
| | | 65.40 | V | 02/23/82 | --- |
| A-13-01 04ABA1 | 4690.00 | 100.68 | S | 09/25/81 | --- |
| A-13-01 04ACA | 4775.00 | 170.46 | S | 09/25/81 | --- |
| A-13-01 04ADA | 4670.00 | 120.00 | R | 08/12/72 | --- |
| A-13-01 04BBC | 4840.00 | 247.00 | S | 09/24/81 | --- |
| | | 170.46 | S | 09/24/81 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area—Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-13-01 05ADC | 4940.00 | 251.41 | S | 09/24/81 | --- |
| A-13-01 05BAC | 4970.00 | 228.82 | S | 09/24/81 | --- |
| A-13-01 05CBA | 5080.00 | 266.31 | S | 09/24/81 | --- |
| A-13-01 05CCC | 5085.00 | 123.17 | S | 09/24/81 | --- |
| A-13-01 05DCC2 | 5020.00 | 385.40 | S | 09/25/81 | --- |
| | | 355.70 | V | 03/01/82 | --- |
| A-13-01 06CBB | 5305.00 | 246.15 | S | 09/23/81 | --- |
| A-13-01 06CDA | 5230.00 | 252.05 | S | 04/01/78 | --- |
| A-13-01 06DBC | 5080.00 | 51.25 | S | 09/23/81 | --- |
| A-13-01 07ABB | 5215.00 | 208.90 | S | 04/01/78 | --- |
| | | 211.77 | S | 03/01/82 | --- |
| A-13-01 07ADC | 5070.00 | 19.10 | S | 04/27/78 | --- |
| | | 18.60 | S | 04/27/78 | --- |
| | | 52.10 | S | 08/31/78 | --- |
| A-13-01 07BBB | 5210.00 | 12.08 | S | 08/24/78 | --- |
| A-13-01 07BCB2 | 5220.00 | 39.32 | S | 08/31/78 | --- |
| A-13-01 07CAD | 5160.00 | 44.85 | S | 08/31/78 | --- |
| A-13-01 07CDD | 5210.00 | 60.10 | S | 04/01/78 | --- |
| | | 57.02 | S | 08/25/78 | --- |
| | | 52.14 | S | 03/01/82 | --- |
| A-13-01 07DCA2 | 5140.00 | 78.75 | S | 08/25/78 | --- |
| A-13-01 07DCC1 | 5185.00 | 94.10 | S | 04/01/78 | --- |
| A-13-01 08ADB | 4880.00 | 17.70 | S | 08/24/78 | --- |
| | | 10.24 | S | 03/01/82 | --- |
| A-13-01 10AAA | 4550.00 | 44.56 | S | 02/25/82 | P |
| A-13-01 10CAD | 4660.00 | 88.76 | S | 11/09/81 | --- |
| A-13-01 10CBD | 4654.00 | 35.46 | S | 09/24/81 | --- |
| A-13-01 10DCC | 4610.00 | 72.19 | S | 11/09/81 | --- |
| A-13-01 11BCB | 4550.00 | 41.74 | S | 11/11/81 | R |
| A-13-01 11BDB | 4550.00 | 46.88 | S | 11/11/81 | --- |
| | | 43.40 | V | 02/25/82 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area—Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-13-01 11CAC | 4525.00 | 48.08 | S | 11/12/81 | --- |
| A-13-01 11CDB | 4520.00 | 37.46 | S | 12/05/56 | P |
| | | 43.40 | --- | 05/27/57 | P |
| | | 38.82 | --- | 12/17/57 | --- |
| | | 37.37 | --- | 03/02/59 | --- |
| | | 76.00 | --- | 03/14/60 | P |
| | | 41.78 | --- | 04/27/61 | --- |
| | | 49.62 | --- | 02/04/63 | S |
| | | 44.23 | --- | 01/14/64 | --- |
| | | 43.50 | --- | 09/20/78 | P |
| A-13-01 11CDD1 | 4525.00 | 28.31 | --- | 10/08/52 | --- |
| | | 35.50 | V | 02/22/82 | --- |
| A-13-01 12ADC | 4871.00 | 361.23 | S | 09/21/81 | --- |
| A-13-01 12BAA | 4655.00 | 144.55 | S | 11/12/81 | --- |
| A-13-01 12BCB | 4630.00 | 121.49 | S | 09/21/81 | --- |
| A-13-01 12CBD | 4650.00 | 140.50 | S | 09/21/81 | --- |
| A-13-01 12CCC | 4570.00 | 70.61 | S | 09/21/81 | --- |
| A-13-01 13ABA | 4665.00 | 159.80 | S | 11/11/81 | --- |
| A-13-01 13CAA | 4650.00 | 104.50 | S | 11/12/81 | --- |
| A-13-01 13CBB | 4540.00 | 50.69 | S | 11/12/81 | --- |
| A-13-01 14ABA | 4540.00 | 53.89 | --- | 12/06/78 | --- |
| A-13-01 14ACB3 | 4500.00 | 25.70 | S | 09/21/78 | --- |
| | | 25.30 | S | 02/22/82 | --- |
| A-13-01 14BBB | 4550.00 | 47.60 | S | 12/05/78 | --- |
| A-13-01 14BCC | 4520.00 | 29.55 | S | 10/04/78 | --- |
| A-13-01 14BDC | 4500.00 | 26.70 | V | 02/22/82 | --- |
| A-13-01 14BDD | 4480.00 | 4.71 | S | 10/04/78 | --- |
| A-13-01 15DBC | 4555.00 | 21.78 | S | 11/09/81 | --- |
| A-13-01 18BAD1 | 5260.00 | 98.00 | S | 08/25/78 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area--Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-13-01 22AAA | 4510.00 | 26.66 | S | 11/12/81 | --- |
| A-13-01 22BAC | 4640.00 | 62.05 | S | 03/01/79 | --- |
| A-13-01 24BAA | 4770.00 | 234.80 | S | 10/05/78 | --- |
| A-13-01H02AAA | 4780.00 | 142.20 | V | 02/24/82 | --- |
| A-13-02 08CDB | 4681.00 | 16.59 | S | 02/24/82 | --- |
| A-13-02 11AAA | 4525.00 | 15.60 | S | 04/20/78 | --- |
| A-13-02 24ACC | 4180.00 | 25.34 | S | 09/05/78 | --- |
| A-13-02 26CBC | 4202.00 | 11.04 | S | 09/05/78 | --- |
| A-13-02 30DBD | 4512.00 | 8.40 | S | 10/18/78 | --- |
| A-13-02 36DDC | 4020.00 | 16.34 | S | 08/31/78 | --- |
| A-13-03 01BDC | 4660.00 | 175.40 | S | 04/19/78 | --- |
| A-13-03 07DBD | 4452.00 | 29.65 | T | 04/20/78 | --- |
| A-13-03 09CBD | 4377.00 | 9.20 | R | 04/20/78 | --- |
| A-13-03 14BCA | 4440.00 | 27.60 | S | 04/19/78 | --- |
| A-13-03 14BCD | 4440.00 | 24.65 | S | 04/19/78 | --- |
| A-13-03 26CDC | 4575.00 | 51.02 | S | 12/15/80 | --- |
| A-13-03 26CDC | 4565.00 | 57.90 | S | 09/05/78 | --- |
| A-13-04 18ADD | 4680.00 | 67.80 | S | 04/19/78 | --- |
| A-14-01 14BBB | 4890.00 | 223.50 | S | 08/12/71 | --- |
| A-14-01 16ACC | 4810.00 | 138.79 | S | 01/26/77 | --- |
| | | 148.55 | --- | 04/25/78 | --- |
| | | 144.82 | --- | 02/28/79 | --- |
| | | 129.30 | --- | 02/06/81 | --- |
| A-14-01 17AAD | 4778.99 | 112.46 | S | 01/15/79 | --- |
| | | 114.30 | --- | 02/06/81 | --- |
| | | 114.40 | V | 07/20/81 | --- |
| | | 114.17 | S | 09/22/81 | --- |
| | | 113.48 | V | 02/23/82 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area--Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-14-01 20CBA1 | 4885.00 | 186.07 | S | 09/23/81 | --- |
| A-14-01 20CBA2 | 4875.00 | 178.00 | --- | 02/07/81 | --- |
| A-14-01 20CDD | 4777.62 | 97.58 | S | 01/15/79 | --- |
| | | 97.82 | S | 09/23/81 | --- |
| A-14-01 21CAA | 4740.00 | 51.57 | S | 11/10/81 | --- |
| A-14-01 22CAD | 4720.00 | 72.10 | S | 04/26/78 | --- |
| | | 67.52 | S | 02/23/82 | --- |
| A-14-01 22DCC | 4710.00 | 51.55 | S | 04/26/78 | --- |
| | | 47.42 | S | 11/13/81 | --- |
| | | 47.80 | S | 02/23/82 | --- |
| A-14-01 24DCB | 4928.00 | 304.80 | V | 05/21/81 | --- |
| | | 304.20 | S | 11/13/81 | --- |
| | | 301.80 | V | 02/23/82 | --- |
| A-14-01 27DBB | 4659.91 | 57.00 | R | 03/18/67 | --- |
| | | 57.40 | --- | 08/12/71 | --- |
| | | 47.54 | S | 02/28/79 | --- |
| | | 58.50 | V | 06/18/81 | --- |
| | | 57.48 | S | 07/20/81 | --- |
| | | 53.77 | S | 08/19/81 | --- |
| | | 51.90 | S | 09/21/81 | --- |
| | | 48.19 | S | 10/21/81 | --- |
| | | 47.30 | S | 11/19/81 | --- |
| | | 47.22 | S | 12/17/81 | --- |
| | | 47.40 | S | 01/19/82 | --- |
| | | 47.69 | S | 02/23/82 | --- |
| | | 47.71 | S | 03/24/82 | --- |
| | | 48.22 | S | 04/20/82 | --- |
| | | 54.12 | S | 05/20/82 | --- |
| | | 57.93 | S | 08/24/82 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area—Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-14-01 28ADA1 | 4689.94 | 30.00 | R | 01/01/36 | --- |
| | | 83.12 | S | 01/15/79 | --- |
| | | 72.21 | S | 11/12/81 | --- |
| | | 67.60 | V | 02/23/82 | --- |
| A-14-01 28ADA2 | 4682.98 | 34.00 | R | 12/30/69 | --- |
| | | 54.90 | S | 04/19/78 | --- |
| | | 82.60 | V | 02/23/82 | --- |
| A-14-01 28BBB | 4714.98 | 48.48 | S | 12/05/56 | --- |
| | | 49.20 | --- | 12/17/57 | --- |
| | | 45.64 | --- | 03/02/59 | --- |
| | | 46.36 | --- | 03/14/60 | --- |
| | | 42.54 | S | 04/17/62 | --- |
| | | 103.00 | --- | 02/04/63 | R |
| | | 49.66 | --- | 01/14/64 | --- |
| | | 51.38 | S | 02/19/65 | --- |
| | | 42.32 | S | 09/23/81 | --- |
| A-14-01 28BCB | 4758.50 | 126.30 | V | 02/28/79 | --- |
| | | 133.67 | S | 09/23/81 | --- |
| A-14-01 28CCA | 4746.60 | 146.60 | S | 04/09/78 | S |
| | | 162.85 | S | 11/10/81 | --- |
| A-14-01 28CDC | 4724.49 | 93.00 | R | 09/18/69 | --- |
| | | 117.90 | --- | 08/12/71 | --- |
| | | 143.43 | S | 11/12/81 | --- |
| A-14-01 28DAC | 4666.38 | 35.86 | S | 12/05/56 | --- |
| | | 83.23 | V | 05/21/81 | --- |
| | | 86.08 | S | 09/22/81 | --- |
| | | 71.75 | S | 02/23/82 | --- |
| A-14-01 29AAA | 4726.02 | 71.20 | --- | 08/12/71 | --- |
| | | 72.60 | T | 01/07/76 | --- |
| | | 69.10 | S | 01/18/77 | --- |
| | | 65.10 | T | 03/14/78 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area—Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-14-01 29AAA | 4726.02 | 59.90 | T | 03/20/79 | --- |
| | | 108.40 | --- | 02/11/81 | --- |
| | | 71.78 | --- | 09/22/81 | --- |
| | | 67.80 | V | 02/25/82 | --- |
| A-14-01 34ACB | 4623.00 | 51.02 | S | 09/20/78 | --- |
| A-14-01 34CAC | 4622.00 | 47.25 | S | 09/20/78 | --- |
| A-14-01 34CDA1 | 4620.00 | 47.70 | S | 09/20/78 | --- |
| A-14-01 35DDA1 | 4705.00 | 152.54 | S | 11/11/81 | --- |
| A-14-01 35DDC1 | 4695.00 | 180.15 | S | 09/13/78 | --- |
| A-14-02 07DDA | 5344.00 | 4.00 | S | 06/20/79 | R |
| | | 8.98 | S | 05/21/81 | --- |
| | | 11.32 | S | 02/23/82 | --- |
| A-14-02H25CCA | 5150.00 | 14.00 | S | 04/20/78 | --- |
| A-15-01 01BCD | 5620.00 | 317.30 | V | 02/24/82 | --- |
| A-15-01 10BCD2 | 5308.00 | 47.40 | V | 02/24/81 | --- |
| | | 44.80 | V | 02/24/82 | --- |
| A-15-01 12ACB | 5610.00 | 344.50 | V | 02/24/82 | --- |
| A-15-01 15CBB | 5230.00 | 37.86 | S | 02/24/82 | --- |
| A-15-01 18CBD | 4937.00 | 382.43 | V | 01/30/77 | --- |
| | | 382.61 | T | 01/24/79 | --- |
| A-15-01 26ABC | 5339.00 | 68.80 | V | 02/24/81 | --- |
| | | 58.03 | S | 11/19/81 | --- |
| | | 59.40 | V | 02/23/82 | --- |
| | | 58.80 | S | 03/24/82 | --- |
| A-15-01 28ACC | 5072.00 | 320.35 | S | 02/27/79 | --- |
| | | 319.00 | --- | 02/06/81 | --- |
| | | 319.40 | V | 03/09/81 | --- |
| | | 316.80 | V | 06/18/81 | --- |
| | | 316.30 | V | 07/20/81 | --- |
| | | 315.20 | V | 08/19/81 | --- |
| | | 315.80 | V | 09/21/81 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area--Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| A-15-01 28ACC | 5072.00 | 313.60 | V | 10/21/81 | --- |
| | | 313.03 | S | 11/10/81 | --- |
| | | 312.84 | S | 11/19/81 | --- |
| | | 313.80 | V | 12/17/81 | --- |
| | | 312.10 | V | 01/19/82 | --- |
| | | 310.00 | V | 02/24/82 | --- |
| | | 310.66 | S | 03/24/82 | --- |
| | | 310.00 | V | 04/20/82 | --- |
| | | 310.45 | S | 05/20/82 | --- |
| | | 309.70 | V | 08/24/82 | --- |
| A-15-02 18DBB UNSU | 5770.00 | 21.70 | S | 07/30/71 | --- |
| A-16-01 21ACA2 | 5349.00 | 108.90 | V | 02/03/81 | P |
| | | 108.80 | V | 02/24/82 | --- |
| A-16-01 27DA UNSUR | 5450.00 | 172.30 | V | 02/24/81 | --- |
| | | 172.90 | V | 02/24/82 | --- |
| B-12H01 20CBC | 6565.00 | 29.70 | V | 03/01/82 | --- |
| B-13-02 26ACC | 6245.00 | 32.66 | --- | 03/15/75 | --- |
| B-13-02 27ADA | 6080.00 | 11.00 | S | 07/01/71 | --- |
| B-14-01 02CBA | 4958.00 | 309.30 | --- | 07/30/71 | --- |
| B-14-01 06ADD | 5203.00 | 681.70 | V | 06/18/81 | R |
| | | 583.60 | V | 07/20/81 | --- |
| | | 582.00 | V | 02/26/82 | --- |
| B-14-01 06BCB | 5030.00 | 267.90 | V | 03/27/63 | --- |
| | | 283.20 | V | 03/12/81 | --- |
| | | 294.30 | V | 02/25/82 | --- |
| B-14-01 10ACD | 5034.83 | 455.10 | V | 02/11/82 | --- |
| | | 456.90 | V | 02/22/82 | --- |
| B-14-01 11ACB | 5043.72 | 337.80 | T | 01/24/79 | --- |
| | | 351.80 | S | 11/13/81 | --- |
| | | 335.60 | V | 02/23/82 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area—Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| B-14-01 11DAA | 5043.52 | 325.60 | V | 01/24/79 | --- |
| | | 324.50 | S | 01/19/81 | --- |
| | | 324.82 | S | 05/29/81 | --- |
| | | 324.88 | S | 06/18/81 | --- |
| | | 324.55 | S | 07/20/81 | --- |
| | | 324.83 | S | 08/19/81 | --- |
| | | 324.36 | S | 09/21/81 | --- |
| | | 324.49 | S | 10/21/81 | --- |
| | | 324.72 | S | 11/13/81 | --- |
| | | 324.50 | S | 11/20/81 | --- |
| | | 324.70 | S | 12/17/81 | --- |
| | | 324.42 | S | 02/23/82 | --- |
| | | 324.56 | S | 03/22/82 | --- |
| | | 324.56 | S | 04/20/82 | --- |
| | | 324.54 | S | 05/20/82 | --- |
| | | 324.64 | S | 06/21/82 | --- |
| | | 324.79 | S | 07/22/82 | --- |
| | | 324.73 | S | 08/24/82 | --- |
| B-14-01 14ACC | 5111.16 | 369.00 | R | 01/01/64 | --- |
| | | 362.50 | T | 04/19/78 | --- |
| | | 372.60 | V | 02/22/82 | --- |
| B-14-01 15ABA | 5117.42 | 454.30 | S | 10/14/71 | --- |
| | | 460.30 | --- | 03/16/72 | --- |
| | | 525.60 | V | 02/11/82 | --- |
| | | 527.10 | V | 02/22/82 | --- |
| B-14-01 18ACA | 5260.00 | 11.21 | S | 03/03/82 | --- |
| B-14-01 22ADA | 5184.10 | 338.00 | R | 03/01/71 | --- |
| | | 337.20 | V | 06/18/81 | --- |
| | | 339.40 | V | 07/20/81 | --- |
| | | 339.00 | V | 08/19/81 | --- |
| | | 339.20 | V | 02/23/82 | --- |

Table 3.--Measurements of water levels in selected wells in the northern part of the Agua Fria area—Continued

| Local number | Altitude | Water level | Method | Date | Status |
|---|---|---|---|---|---|
| B-14-01 22ADA | 5184.10 | 339.90 | S | 03/24/82 | --- |
| | | 339.40 | V | 04/20/82 | --- |
| | | 340.20 | V | 05/20/82 | --- |
| | | 340.20 | V | 08/24/82 | --- |
| B-14-01 22BDC | 5221.44 | 205.00 | S | 07/01/71 | --- |
| | | 197.02 | S | 01/15/79 | --- |
| | | 192.67 | S | 09/23/81 | --- |
| | | 191.40 | V | 02/23/82 | --- |
| B-14-01 24DCC | 5080.00 | 256.20 | S | 09/24/81 | --- |
| B-14-01 25DAC | 4933.00 | 48.20 | S | 04/19/78 | --- |
| | | 40.78 | --- | 06/20/79 | --- |
| | | 45.42 | S | 09/24/81 | --- |
| | | 45.27 | S | 02/23/82 | --- |
| B-14-01 26AAA | 5120.00 | 207.20 | V | 04/26/78 | --- |
| | | 207.62 | S | 09/23/81 | --- |
| | | 207.30 | V | 02/23/82 | --- |
| B-14-01 26CCD | 5180.00 | 52.10 | S | 04/19/78 | --- |
| B-14-01 27DCC | 5265.00 | 55.60 | S | 04/18/78 | X |
| | | 56.89 | S | 02/23/82 | --- |
| B-14-01 31BBC | 5585.00 | 30.60 | S | 03/03/82 | --- |

Table 4.--Records of selected springs in the northern part of the Agua Fria area

Local number: See figure for description of well-numbering and location system; UN, unsurveyed.

Use: C, commercial; E, power; H, domestic; I, irrigation; P, public supply; R, recreation; S, stock; T, institution; U, unused; Z, other.

Type: K, artesian and seepage or filtration; C, contact; S, seepage or filtration; F, fracture.

Permanence: P, perennial; I, intermittent.

Altitude of land surface: In feet above sea level; determined from U.S. Geological Survey topographic maps.

Discharge: C, current meter; E, estimated; V, volumetric; W, weir.

| Local Number | Use | Type | Permanence | Altitude of land surface (feet) | Discharge (gallons per minute) | Date measured | Temperature (°C) | Specific conductance (microsiemen per centimeter at 25°C) | Spring |
|---|---|---|---|---|---|---|---|---|---|
| A-10-02 02DDD | S | K | --- | 3,450 | ------ | -------- | ---- | 690 | BADGER |
| A-11-04 01CCD | S | C | P | 4,710 | 14 F | 10/23/80 | 12.0 | ----- | WILLOW |
| A-11-05 21ADA UN | S | C | P | 5,250 | 96 C | 06/05/81 | 10.0 | ----- | NELSON PLACE |
| A-11-05 22BCD UN | S | S | P | 5,250 | 50 E | 12/13/80 | ---- | ----- | BEE HOUSE CN |
| A-12-01 02AAD | H,S | F | P | 4,240 | ------ | -------- | ---- | 860 | LESSARD |
| A-12-01 23BBA | S | --- | --- | 4,470 | ------ | -------- | 15.5 | 1,465 | DANDREA |
| A-12-03 01CAC | S | --- | --- | 4,280 | .10E | 09/05/78 | ---- | 615 | ASH |
| A-12-03 28DBA | S | --- | --- | 3,840 | .10E | 08/31/78 | 29.0 | 510 | ---------- |
| A-12-03 35BAA | S,Z | --- | --- | 3,920 | 40 E | 08/31/78 | 24.0 | 460 | BROWN |
| A-13-01 07ADC | S | F | --- | 5,040 | 2.0 V | 06/18/79 | 18.0 | 1,100 | ---------- |
| A-13-01 20DDD | U | F | --- | 4,770 | 5.0 E | 10/20/78 | 15.5 | 2,050 | ---------- |
| A-13-01 29AAC | U | F | I | 4,840 | ------ | -------- | 16.0 | 2,140 | ---------- |
| A-13-01 29BDB | U | F | P | 4,960 | 1.0 V | 10/20/78 | 16.5 | 3,050 | ---------- |
| A-13-03 33CAD | S,Z | --- | --- | 4,250 | 2.0 E | 09/05/78 | ---- | 650 | GOVERNMENT |
| A-15-01 01ABA | S | --- | --- | 5,780 | 1.3 V | 02/24/81 | ---- | 635 | ---------- |
| A-15-02 06BC UN | H,S | --- | P | 5,970 | 9.4 V | 02/24/81 | 14.0 | 480 | COYOTE |
| A-15-02 30AAB UN | S | --- | --- | 5,835 | .40V | 02/24/82 | 13.0 | 460 | TIN TANK |
| B-12H01 22DCC | S | C | --- | 5,910 | ----- | -------- | 15.0 | 1,100 | POSTMASTER |

Table 5.--Records of selected wells in the northern part of the Agua Fria area

Local number: See figure 2 for description of well-numbering and location system. UN, unsurveyed.

Method constructed: A, air rotary; B, bored or augered; C, cable tool; D, dug; H, hydraulic rotary; P, air percussion.

Finish: C, porous concrete; O, open end; P, perforated or slotted; X, open hole.

Depth to first opening: Depth in feet below land surface, to top of first perforated interval.

Use of water: C, commercial; H, domestic; I, irrigation; N, industrial; P, public supply; R, recreation; S, stock; T, institution; U, unused.

Depth of well: In feet below land surface.

Altitude of land surface: In feet above sea level, determined from U.S. Geological Survey topographic maps or engineer's level lines.

Discharge: B, bailer; C, current meter; E, estimated; O, orifice; R, reported; W, weir.

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-10-02 17DBA | -- | -- | -- | -- | -- | S | -- | 2,925 | -- | -- |
| A-10-02 17DDA | -- | -- | -- | -- | -- | -- | -- | 2,900 | -- | -- |
| A-10-02 23ADD | -- | -- | -- | -- | 6 | S | 100 | 3,200 | -- | -- |
| A-10-02 24BCC | -- | -- | -- | -- | -- | S | 120 | 3,200 | -- | -- |
| A-10-03 08ADD | -- | D | -- | -- | -- | -- | 30 | 3,250 | -- | -- |
| A-10-03 08DAA | -- | -- | P | -- | 14 | H,S,I | 55 | 3,250 | -- | -- |
| A-10-04 14CCD | -- | -- | -- | -- | -- | -- | -- | 4,370 | -- | -- |
| A-11-02 02ABB1 | -- | -- | -- | -- | -- | S | -- | 3,711 | -- | -- |
| A-11-02 02ABB2 | -- | -- | -- | -- | -- | -- | -- | 3,715 | -- | -- |
| A-11-02 03BCC | -- | -- | -- | -- | -- | H | -- | 4,060 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-11-02 05BAA1 | 06/ /76 | H | -- | 105 | 8 | H | 365 | 4,150 | -- | -- |
| A-11-02 05BAA2 | 06/ /76 | H | -- | 20 | 6 | H | 450 | 4,120 | -- | -- |
| A-11-02 06ABA | 1961 | -- | P | 30 | 6 | H | 145 | 4,060 | -- | -- |
| A-11-02 09BCC | 02/05/48 | C | X | 22 | 12 | U | 78 | 3,950 | -- | -- |
| A-11-02 09CCB | -- | -- | -- | -- | -- | -- | -- | 3,925 | -- | -- |
| A-11-02 09CCC | 09/16/72 | C | -- | 100 | 10.88 | H | 302 | 3,940 | -- | -- |
| A-11-02 09CCD | -- | -- | -- | -- | 8 | P | -- | 3,920 | -- | -- |
| A-11-02 09DBD | 09/17/76 | A | P | 145 | 5.58 | T | 305 | 3,970 | -- | -- |
| A-11-02 09DDD | -- | -- | -- | -- | 8 | P | -- | 3,885 | -- | -- |
| A-11-02 11CCA | -- | -- | -- | -- | -- | S | -- | 3,820 | -- | -- |
| A-11-02 12BDA | -- | -- | X | 10 | 8 | H | -- | 3,620 | -- | -- |
| A-11-02 12DDA | -- | -- | -- | -- | 12 | H | 65 | 3,580 | -- | -- |
| A-11-02 14ADB | -- | -- | -- | -- | 6 | H | 250 | 3,800 | -- | -- |
| A-11-02 14BAC | 1969 | -- | X | 10 | 8 | H | 160 | 3,815 | -- | -- |
| A-11-02 14BDD | -- | -- | -- | -- | -- | H | -- | 3,830 | -- | -- |
| A-11-02 14CAA | 08/ /78 | -- | P | 100 | 8 | H | 200 | 3,805 | 112 | 09/07/78 |
| A-11-02 14CAD | -- | -- | -- | -- | -- | H | -- | 3,805 | -- | -- |
| A-11-02 14CBB1 | -- | -- | -- | -- | -- | H | -- | 3,805 | -- | -- |
| A-11-02 14CBB2 | -- | -- | -- | -- | -- | -- | -- | 3,800 | -- | -- |
| A-11-02 14CCA | 01/ /74 | -- | X | 140 | 6 | H | 220 | 3,810 | -- | -- |
| A-11-02 14CCD1 | 01/ /63 | -- | -- | -- | 6 | H | 50 | 3,760 | -- | -- |
| A-11-02 14CCD2 | 01/ /66 | -- | -- | -- | 12 | H | 50 | 3,790 | -- | -- |
| A-11-02 14DAC | -- | -- | -- | -- | -- | H | 310 | 3,760 | -- | -- |
| A-11-02 14DAD | 07/ /75 | -- | -- | -- | -- | H | -- | 3,745 | -- | -- |
| A-11-02 14DCC2 | 01/ /78 | C | -- | -- | 6 | H | 235 | 3,780 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-11-02 14DCD1 | 01/16/74 | C | -- | 10 | 8.60 | H | 195 | 3,760 | -- | -- |
| A-11-02 14DCD2 | -- | -- | -- | -- | -- | H | -- | 3,765 | -- | -- |
| A-11-02 14DCD3 | -- | -- | -- | -- | -- | H | -- | 3,765 | -- | -- |
| A-11-02 14DDC | -- | -- | -- | -- | -- | H | -- | 3,755 | -- | -- |
| A-11-02 15ACA | 08/31/77 | H | X | 29 | 8 | H | 240 | 3,890 | -- | -- |
| A-11-02 15ADB | 1971 | -- | X | 32 | 8 | H | 200 | 3,900 | -- | -- |
| A-11-02 16BBA | 11/10/75 | H | X | 25 | 6 | U | 385 | 3,930 | -- | -- |
| A-11-02 20BAB | -- | -- | -- | -- | -- | S | -- | 3,930 | -- | -- |
| A-11-02 23ABA | -- | -- | -- | -- | -- | -- | -- | 3,770 | -- | -- |
| A-11-02 23ABB1 | 06/ /78 | C | -- | -- | 6 | -- | 100 | 3,780 | -- | -- |
| A-11-02 23ABB2 | 08/ /78 | C | X | 10 | 8 | -- | 175 | 3,780 | -- | -- |
| A-11-02 24BBB | -- | C | -- | -- | 6 | -- | 200 | 3,730 | -- | -- |
| A-11-02 24CAD | -- | -- | -- | -- | -- | P | -- | 3,690 | -- | -- |
| A-11-02 24DDB | 03/17/77 | C | P | 105 | 6.62 | H | 205 | 3,635 | -- | -- |
| A-11-02 25AAB | 07/30/66 | -- | -- | -- | 6 | U | -- | 3,640 | -- | -- |
| A-11-02 25ACD | -- | -- | -- | -- | -- | R | -- | 3,685 | -- | -- |
| A-11-02 25BCB | -- | -- | -- | -- | 10 | S | -- | 3,678 | -- | -- |
| A-11-02 25BDD | 01/ /68 | -- | -- | -- | -- | P | -- | 3,700 | -- | -- |
| A-11-02 29DAA | -- | D | X | 0 | -- | H | 14 | 3,770 | -- | -- |
| A-11-03 17CCC | -- | -- | -- | -- | -- | H | -- | 3,540 | -- | -- |
| A-11-03 18AAD | 1971 | -- | -- | -- | 6 | -- | 145 | 3,560 | -- | -- |
| A-11-03 18ADA | -- | -- | -- | -- | 8 | -- | 35 | 3,555 | -- | -- |
| A-11-03 18DBA | 02/ /52 | -- | P | 25 | 20 | I | 85 | 3,560 | -- | -- |
| A-11-03 18DDB | -- | -- | -- | -- | -- | -- | -- | 3,560 | -- | -- |
| A-11-04 01CBB | 1980 | D | -- | -- | 48 | S | -- | 4,713 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-12-01 02DAA1 | 01/ /54 | -- | -- | -- | 16 | -- | 50 | 4,120 | -- | -- |
| A-12-01 02DAA2 | 01/ /54 | -- | -- | -- | 16 | -- | 50 | 4,120 | -- | -- |
| A-12-01 04BBC1 | 07/ /73 | -- | -- | -- | -- | -- | 305 | 4,930 | -- | -- |
| A-12-01 04BBC2 | 07/ /73 | -- | -- | -- | -- | H | 165 | 4,930 | -- | -- |
| A-12-01 04BBC3 | 03/ /74 | -- | -- | -- | -- | S | 458 | 4,918 | -- | -- |
| A-12-01 04BBC4 | 08/ /75 | -- | -- | -- | -- | -- | 425 | 4,920 | -- | -- |
| A-12-01 04BBC5 | 07/ /76 | -- | -- | -- | -- | H | 125 | 4,920 | -- | -- |
| A-12-01 04BDA | 09/20/76 | -- | X | 10 | 10.62 | H | 200 | 4,890 | -- | -- |
| A-12-01 04CAA1 | 05/01/72 | -- | -- | -- | -- | P | 129 | 4,850 | -- | -- |
| A-12-01 04CAA2 | 07/28/77 | -- | -- | -- | -- | -- | 149 | 4,850 | -- | -- |
| A-12-01 05CAA1 | 01/ /34 | -- | X | 10 | 60 | H | 30 | 4,830 | -- | -- |
| A-12-01 05CAA2 | -- | -- | -- | -- | -- | H | -- | 4,830 | -- | -- |
| A-12-01 05CAB | -- | -- | X | 10 | 48 | H | 24 | 4,840 | -- | -- |
| A-12-01 09BCB | -- | -- | -- | -- | -- | H | -- | 4,720 | -- | -- |
| A-12-01 09CCB1 | 01/ /68 | -- | P | 20 | 8 | H | 75 | 4,640 | -- | -- |
| A-12-01 09CCB2 | 01/ /70 | C | P | -- | 6 | H | 200 | 4,640 | -- | -- |
| A-12-01 09DCC1 | 01/ /65 | -- | -- | -- | -- | S | 280 | 4,640 | -- | -- |
| A-12-01 09DCC2 | 01/ /70 | -- | -- | -- | 8 | H | 70 | 4,620 | -- | -- |
| A-12-01 15CDB | 01/ /68 | -- | X | 10 | 10 | H | 47 | 4,550 | -- | -- |
| A-12-01 22BBB1 | -- | -- | -- | -- | 6.50 | H,S | 38 | 4,470 | -- | -- |
| A-12-01 22BBB2 | 09/ /78 | -- | X | 86 | 6 | S | 250 | 4,470 | -- | -- |
| A-12-01 22BBC | 03/ /77 | -- | -- | -- | 6 | -- | 150 | 4,470 | -- | -- |
| A-12-01 22BCA | 01/ /77 | -- | P | 0 | 6 | H,I,S | 236 | 4,445 | -- | -- |
| A-12-01 22BCD | 01/ /75 | -- | X | 20 | 6 | H,I,S | 226 | 4,440 | -- | -- |
| A-12-01 22CAB | -- | -- | -- | -- | -- | -- | 17 | 4,410 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-12-01 22CDA | 08/ /78 | -- | P | 30 | 6 | H | 400 | 4,410 | -- | -- |
| A-12-01 22DDD | 01/ /25 | -- | X | 20 | 60 | I | 30 | 4,370 | -- | -- |
| A-12-01 24CDC | -- | -- | -- | -- | 7 | S | 140 | 4,408 | -- | -- |
| A-12-01 26BAA1 | 01/ /55 | -- | P | 30 | 8 | P | 70 | 4,360 | -- | -- |
| A-12-01 26BAA2 | 01/ /55 | -- | X | 100 | 8 | P | 200 | 4,350 | -- | -- |
| A-12-01 26BAA3 | 01/ /63 | -- | P | 150 | 8 | H | 500 | 4,350 | -- | -- |
| A-12-01 26BAA4 | 01/ /70 | -- | -- | -- | 6 | -- | 140 | 4,360 | -- | -- |
| A-12-01 26BAA5 | 01/ /72 | -- | -- | -- | 8 | -- | 200 | 4,360 | -- | -- |
| A-12-01 26BAB | 06/28/76 | C | X | 8 | 10.62 | I | 210 | 4,375 | -- | -- |
| A-12-01 26BBB | -- | -- | -- | -- | 8 | H | 127 | 4,390 | -- | -- |
| A-12-01 26DAB | 1955 | -- | X | -- | -- | H | 60 | 4,260 | -- | -- |
| A-12-01 26DDD | 01/ /74 | -- | P | 50 | 6 | H | 450 | 4,310 | -- | -- |
| A-12-01 27DBA1 | -- | -- | -- | -- | 13 | P | 94 | 4,475 | -- | -- |
| A-12-01 27DBA2 | 02/16/73 | C | X | 10 | 12.75 | P | 136 | 4,475 | -- | -- |
| A-12-01 29DAC | -- | -- | -- | -- | 6 | S | 90 | 4,900 | -- | -- |
| A-12-01 31BCC | -- | -- | -- | -- | 6 | S | 65 | 5,300 | -- | -- |
| A-12-01 33AAD | -- | -- | -- | -- | 6.50 | H,S | 185 | 4,645 | -- | -- |
| A-12-01 33ADA | -- | -- | -- | -- | 6 | H,S | 160 | 4,640 | -- | -- |
| A-12-01 33ADB | -- | -- | -- | -- | 6.50 | S | 140 | 4,640 | -- | -- |
| A-12-01 33ADD | -- | -- | -- | -- | 7 | I | 180 | 4,635 | -- | -- |
| A-12-01 34ACC | -- | -- | -- | -- | 4 | -- | 34 | 4,535 | -- | -- |
| A-12-01 34DAC1 | 01/ /75 | -- | -- | -- | 8 | H,S | 200 | 4,480 | -- | -- |
| A-12-01 34DAC2 | 04/11/78 | -- | P | 100 | 6.50 | -- | 160 | 4,480 | -- | -- |
| A-12-01 34DBB | -- | -- | -- | -- | -- | H | -- | 4,525 | -- | -- |
| A-12-01 36ABD | 01/ /76 | -- | X | 7 | 8 | H | 435 | 4,210 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-12-02 01DAC | -- | -- | -- | -- | -- | S | 250 | 4,070 | -- | -- |
| A-12-02 04AAD | 03/ /77 | -- | -- | -- | 6.50 | S | 109 | 4,210 | -- | -- |
| A-12-02 08ACC | -- | -- | -- | -- | -- | I | 50 | 3,974 | -- | -- |
| A-12-02 08DBA | -- | -- | -- | -- | -- | I | 60 | 3,965 | -- | -- |
| A-12-02 22BCD | -- | -- | -- | -- | 18 | I | -- | 3,812 | 1000W | 12/00/46 |
| A-12-02 22CDC | -- | -- | -- | -- | -- | H | -- | 3,780 | -- | -- |
| A-12-02 22CDD | -- | -- | -- | -- | -- | -- | -- | 3,780 | -- | -- |
| A-12-02 23BAA | -- | -- | -- | -- | -- | S | 140 | 3,870 | -- | -- |
| A-12-02 27ACB | -- | -- | -- | -- | -- | -- | 34 | 3,770 | -- | -- |
| A-12-02 27BAD | -- | -- | -- | -- | -- | -- | -- | 3,775 | -- | -- |
| A-12-02 27BDA1 | -- | -- | -- | -- | 16 | I | 395 | 3,766 | -- | -- |
| A-12-02 27BDA2 | -- | -- | -- | -- | -- | -- | -- | 3,766 | -- | -- |
| A-12-02 27BDA3 | 08/27/71 | -- | -- | -- | 6.50 | H,S | 222 | 3,766 | -- | -- |
| A-12-02 27DDB | -- | -- | -- | -- | -- | H,S | -- | 3,750 | -- | -- |
| A-12-02 28CBD | -- | -- | -- | -- | -- | S | -- | 4,000 | -- | -- |
| A-12-02 29AA | -- | -- | -- | -- | -- | -- | -- | 4,200 | -- | -- |
| A-12-02 29ACD | -- | -- | -- | -- | -- | S | -- | 4,100 | -- | -- |
| A-12-02 31BDD | 01/ /52 | -- | P | 15 | 6 | H | 50 | 4,120 | -- | -- |
| A-12-02 35DCC1 | 1962 | -- | P | -- | 20 | -- | 246 | 3,700 | -- | -- |
| A-12-02 35DCC2 | -- | -- | -- | -- | -- | -- | -- | 3,700 | -- | -- |
| A-12-03 08BDD | -- | -- | -- | -- | -- | H | -- | 3,870 | -- | -- |
| A-12-03 10BAB | 01/ /74 | -- | -- | -- | -- | S | -- | 4,110 | -- | -- |
| A-12-03 11BBC | -- | -- | -- | -- | -- | S | 80 | 4,130 | -- | -- |
| A-12-03 12CDD | 05/11/63 | -- | -- | 20 | 6 | S | -- | 4,230 | -- | -- |
| A-12-03 17CCB | 03/ /41 | -- | P | 8 | 16 | I | 65 | 3,815 | 625C | 09/01/78 |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-12-03 20BCD | 05/ /42 | -- | P | 25 | 12 | I | 100 | 3,790 | 210C | 09/01/78 |
| A-12-03 22BBC | -- | -- | -- | -- | -- | S | 180 | 3,955 | 1.0E | 08/31/78 |
| A-12-03 23BDA | -- | -- | -- | -- | -- | S | 240 | 4,135 | -- | -- |
| A-12-04 18AAA | -- | -- | -- | -- | 8 | S | -- | 4,260 | -- | -- |
| A-13-01 01AAC | 1980 | -- | -- | -- | 6 | I | -- | 4,745 | -- | -- |
| A-13-01 01ACC | 08/15/78 | -- | P | 200 | 8 | -- | 300 | 4,705 | -- | -- |
| A-13-01 01BAA | 1981 | -- | -- | -- | 8 | H | -- | 4,680 | -- | -- |
| A-13-01 01BDA | 06/02/78 | -- | P | 252 | 8.60 | H,S | 350 | 4,690 | -- | -- |
| A-13-01 01CBB | 11/ /80 | C | -- | -- | 6 | H,S | 290 | 4,620 | -- | -- |
| A-13-01 01CCD | 08/19/78 | -- | P | 150 | 6 | -- | 250 | 4,640 | -- | -- |
| A-13-01 01DBB | 12/ /79 | A | P | 160 | 8 | H,I | 400 | 4,690 | -- | -- |
| A-13-01 01DCA | 1980 | -- | -- | -- | 8 | H | -- | 4,740 | -- | -- |
| A-13-01 02CAC | 1968 | C | P | 90 | 8 | S | 200 | 4,603 | 75B | -- |
| A-13-01 02CCB | 01/ /50 | -- | -- | -- | 8 | H | 250 | 4,560 | -- | -- |
| A-13-01 02CCD | -- | -- | -- | -- | 6 | H | -- | 4,560 | -- | -- |
| A-13-01 02DCA | 01/ /37 | -- | -- | -- | 20 | I,H | 850 | 4,585 | -- | -- |
| A-13-01 02DDD | 03/29/77 | C | P | 100 | 8.62 | H,S,I | 251 | 4,610 | 120B | 03/29/77 |
| A-13-01 03ABB | -- | -- | -- | -- | 10 | H,I | 194 | 4,602 | -- | -- |
| A-13-01 03ACD | 01/03/74 | -- | P | 100 | 8 | H | 162 | 4,590 | -- | -- |
| A-13-01 03ADA | 06/15/51 | -- | -- | -- | 12.75 | I | -- | 4,580 | -- | -- |
| A-13-01 03ADC | -- | -- | -- | -- | -- | H | 90 | 4,580 | -- | -- |
| A-13-01 03BBC | 02/17/73 | C | P | 118 | 6 | H | 139 | 4,645 | -- | -- |
| A-13-01 03BCA | -- | -- | X | 100 | 6 | -- | 150 | 4,640 | -- | -- |
| A-13-01 03BCD | -- | -- | P | 90 | 6 | H | 128 | 4,635 | -- | -- |
| A-13-01 03BDA1 | 1960 | -- | -- | -- | 6 | H | 150 | 4,600 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-13-01 03BDA2 | 1973 | C | -- | -- | 6 | H | 140 | 4,600 | -- | -- |
| A-13-01 03BDA3 | 1973 | C | P | 160 | 6 | U | 179 | 4,600 | -- | -- |
| A-13-01 03BDC | 1972 | C | P | 110 | 6 | -- | 135 | 4,610 | -- | -- |
| A-13-01 03CAA | -- | -- | P | 80 | 8 | H | 139 | 4,630 | -- | -- |
| A-13-01 03CAB | 1973 | -- | -- | -- | 6 | H | 135 | 4,620 | -- | -- |
| A-13-01 03CBA | 06/19/78 | -- | X | 45 | 6 | H | 150 | 4,640 | -- | -- |
| A-13-01 03CCA | 06/ /78 | A | -- | -- | -- | -- | -- | 4,700 | -- | -- |
| A-13-01 03DAC | 01/ /70 | -- | -- | -- | 6 | H | 112 | 4,555 | -- | -- |
| A-13-01 03DBB | 02/24/73 | -- | P | 135 | 6 | H | 153 | 4,600 | -- | -- |
| A-13-01 03DBC1 | -- | -- | -- | -- | 6 | I | 105 | 4,610 | -- | -- |
| A-13-01 03DBC2 | 02/24/73 | C | P | 135 | 6 | H | 153 | 4,610 | -- | -- |
| A-13-01 03DCA | 01/ /77 | -- | P | 186 | 4 | H | 206 | 4,580 | -- | -- |
| A-13-01 03DCB | 01/ /75 | -- | P | -- | 6 | H | 118 | 4,600 | -- | -- |
| A-13-01 04ABA1 | 01/ /78 | -- | -- | -- | 8 | H | 160 | 4,690 | -- | -- |
| A-13-01 04ABA2 | 01/ /78 | -- | -- | -- | 6 | H | 187 | 4,695 | -- | -- |
| A-13-01 04ACA | -- | -- | -- | -- | -- | H | -- | 4,775 | -- | -- |
| A-13-01 04ADA | 1972 | C | P | 200 | 6 | H | 250 | 4,670 | -- | -- |
| A-13-01 04BBC | 12/14/75 | C | -- | 10 | 10 | H | 325 | 4,840 | -- | -- |
| A-13-01 04BCB | 06/05/76 | C | X | 10 | 6.62 | H | 245 | 4,790 | 40B | 06/05/76 |
| A-13-01 05ADC | 07/05/78 | A | P | -- | 6 | H | 300 | 4,940 | -- | -- |
| A-13-01 05BAC | 08/29/79 | A | P | 230 | 5.56 | H | 330 | 4,970 | -- | -- |
| A-13-01 05CAB1 | 01/ /78 | -- | X | 60 | 6 | -- | 305 | 5,020 | -- | -- |
| A-13-01 05CAB2 | 05/ /78 | -- | -- | -- | 5 | H | 300 | 5,020 | -- | -- |
| A-13-01 05CBA | 01/ /74 | -- | P | 278 | 6 | H | 318 | 5,080 | -- | -- |
| A-13-01 05CCC | 08/ /79 | A | P | 320 | 5 | H | 440 | 5,085 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-13-01 05DCC1 | 10/16/73 | -- | P | 150 | 6 | H | 315 | 5,000 | -- | -- |
| A-13-01 05DCC2 | 07/07/78 | -- | P | 410 | 5.50 | H | 460 | 5,020 | -- | -- |
| A-13-01 05DDA1 | -- | -- | -- | -- | 6 | H | 125 | -- | -- | -- |
| A-13-01 05DDA2 | -- | -- | X | 0 | -- | S | 100 | -- | -- | -- |
| A-13-01 06CBB | 01/02/79 | A | P | 315 | 5 | H | 458 | 5,305 | -- | -- |
| A-13-01 06CCB | -- | -- | -- | -- | 6 | H | 335 | 5,320 | -- | -- |
| A-13-01 06CDA | -- | -- | -- | -- | 6 | H | 328 | 5,230 | -- | -- |
| A-13-01 06DBC | 05/ /80 | A | P | 75 | 5 | H | 140 | 5,080 | -- | -- |
| A-13-01 07ABA | 05/ /78 | -- | X | 240 | 5 | H | 380 | 5,180 | -- | -- |
| A-13-01 07ABB | 11/ /74 | -- | X | 229 | 6 | H | 465 | 5,215 | -- | -- |
| A-13-01 07ACA | 01/ /67 | -- | X | 18 | 8 | H | 289 | 5,115 | -- | -- |
| A-13-01 07ACD | 01/ /76 | -- | X | 20 | 5.50 | H | 165 | 5,090 | -- | -- |
| A-13-01 07ADC | 01/ /71 | A | -- | -- | 6 | H | 350 | 5,070 | -- | -- |
| A-13-01 07BBB | 01/ /12 | D | W | -- | 36 | H | 26 | 5,210 | -- | -- |
| A-13-01 07BCB1 | 01/ /71 | -- | X | 60 | 8 | H | 89 | 5,240 | -- | -- |
| A-13-01 07BCB2 | 08/ /78 | -- | X | 30 | 6 | H | 200 | 5,220 | -- | -- |
| A-13-01 07BDB | -- | -- | P | 182 | 5 | H | 212 | 5,170 | -- | -- |
| A-13-01 07BDD | -- | -- | -- | -- | -- | -- | -- | 5,155 | -- | -- |
| A-13-01 07CAD | 01/ /68 | -- | -- | -- | 6 | H | 53 | 5,160 | -- | -- |
| A-13-01 07CBC | 10/23/77 | -- | X | 20 | 8 | -- | 120 | 5,280 | -- | -- |
| A-13-01 07CDD | 11/ /77 | -- | X | 100 | 6 | Z | 160 | 5,210 | -- | -- |
| A-13-01 07DAB | -- | -- | -- | -- | 8 | H | 36 | 5,090 | -- | -- |
| A-13-01 07DBB | 01/06/78 | -- | X | 95 | 5.37 | H | 125 | 5,145 | -- | -- |
| A-13-01 07DCA1 | -- | -- | X | 12 | 6 | H | 210 | 5,140 | -- | -- |
| A-13-01 07DCA2 | 06/18/77 | -- | X | 12 | 6 | S | 305 | 5,140 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-13-01 07DCC1 | 01/ /70 | -- | X | 90 | 6 | H | 280 | 5,185 | -- | -- |
| A-13-01 07DCC2 | -- | -- | -- | -- | -- | H | 150 | 5,185 | -- | -- |
| A-13-01 07DDC | 01/ /70 | -- | -- | -- | 8 | H | 180 | 5,180 | -- | -- |
| A-13-01 08ADB | -- | -- | -- | -- | 6 | -- | 23 | 4,880 | -- | -- |
| A-13-01 10AAA | 01/ /54 | -- | P | 40 | 12 | I | 500 | 4,550 | -- | -- |
| A-13-01 10CAD | -- | -- | -- | -- | 5 | H | -- | 4,660 | -- | -- |
| A-13-01 10CBD | -- | -- | -- | -- | 6 | H | 130 | 4,654 | -- | -- |
| A-13-01 10DCC | -- | -- | -- | -- | 5 | H | -- | 4,610 | -- | -- |
| A-13-01 11AAC | 02/11/77 | C | P | 60 | 6 | H | 180 | 4,580 | -- | -- |
| A-13-01 11ABB | 08/10/77 | -- | P | 120 | 6 | H | 150 | 4,560 | -- | -- |
| A-13-01 11ADC | 10/22/77 | -- | P | 120 | 8 | H | 200 | 4,590 | -- | -- |
| A-13-01 11BCA1 | 01/ /46 | -- | P | 150 | 10 | I,S | 482 | 4,540 | -- | -- |
| A-13-01 11BCA2 | 01/ /47 | -- | X | 103 | 12 | I | 375 | 4,540 | -- | -- |
| A-13-01 11BCB | 01/ /00 | -- | -- | -- | 16 | H | 80 | 4,550 | -- | -- |
| A-13-01 11BDB | 01/ /39 | -- | X | 62 | 16 | I | 850 | 4,550 | -- | -- |
| A-13-01 11CAC | -- | -- | -- | -- | 6 | N | -- | 4,525 | 100R | 11/12/81 |
| A-13-01 11CDB | -- | -- | -- | -- | -- | I,H | 800 | 4,520 | -- | -- |
| A-13-01 11CDD1 | -- | -- | -- | -- | 16 | -- | 80 | 4,525 | -- | -- |
| A-13-01 11CDD2 | 07/ /60 | -- | P | 385 | 12 | -- | 1395 | 4,525 | -- | -- |
| A-13-01 12AAB | 09/05/81 | C | P | -- | 6 | H | -- | 4,770 | -- | -- |
| A-13-01 12ADC | 11/10/79 | C | P | -- | 4 | H | 515 | 4,871 | -- | -- |
| A-13-01 12BAA | 03/10/77 | -- | P | 10 | 10 | I | 455 | 4,655 | 480W | 03/14/77 |
| A-13-01 12BBA | 01/ /74 | -- | -- | -- | 6 | H | 225 | 4,620 | -- | -- |
| A-13-01 12BBB | 12/21/74 | -- | P | 142 | 6 | H,S | 225 | 4,600 | -- | -- |
| A-13-01 12BCB | -- | -- | -- | -- | 6 | H | -- | 4,630 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-13-01 12CBD | 10/15/80 | A | P | 165 | 5 | H | 200 | 4,650 | -- | -- |
| A-13-01 12CCC | 09/24/80 | A | P | 108 | 5 | H | 138 | 4,570 | -- | -- |
| A-13-01 13ABA | 06/ /81 | C | P | -- | 6 | H | 309 | 4,665 | -- | -- |
| A-13-01 13CAA | 05/13/80 | A | P | 200 | 5 | H | 260 | 4,650 | -- | -- |
| A-13-01 13CBB | 04/21/76 | -- | -- | -- | -- | H | 203 | 4,540 | -- | -- |
| A-13-01 13DBC | 01/ /73 | -- | X | 58 | 6 | H | 258 | 4,680 | -- | -- |
| A-13-01 14ABA | -- | -- | -- | -- | -- | -- | -- | 4,540 | -- | -- |
| A-13-01 14ACB1 | -- | -- | -- | -- | -- | P | 46 | 4,500 | -- | -- |
| A-13-01 14ACB2 | -- | -- | -- | -- | -- | P | 54 | 4,500 | -- | -- |
| A-13-01 14ACB3 | -- | -- | -- | -- | 16 | -- | 72 | 4,500 | -- | -- |
| A-13-01 14BBA1 | 01/ /57 | C | P | 40 | 6 | -- | 130 | 4,540 | -- | -- |
| A-13-01 14BBA2 | -- | -- | -- | -- | -- | H | -- | 4,540 | -- | -- |
| A-13-01 14BBB | 10/20/73 | -- | P | 50 | 10 | H | 210 | 4,550 | -- | -- |
| A-13-01 14BCC | 01/ /64 | -- | -- | -- | -- | -- | -- | 4,520 | -- | -- |
| A-13-01 14BCD1 | -- | -- | -- | -- | 6 | H | 90 | 4,520 | -- | -- |
| A-13-01 14BCD2 | 01/ /53 | -- | -- | -- | -- | I | 170 | 4,515 | -- | -- |
| A-13-01 14BDC | -- | -- | -- | -- | 6 | P | 219 | 4,500 | -- | -- |
| A-13-01 14CBA1 | -- | -- | -- | -- | -- | H | -- | 4,500 | -- | -- |
| A-13-01 14CBA2 | 12/07/76 | -- | P | 45 | 6 | P | 125 | 4,500 | -- | -- |
| A-13-01 14DDB1 | 06/06/77 | -- | X | 10 | 10 | -- | 150 | 4,530 | -- | -- |
| A-13-01 14DDB2 | 01/ /77 | -- | X | 20 | 10 | H | 185 | 4,530 | -- | -- |
| A-13-01 15DBC | -- | D | -- | -- | -- | H | 36 | 4,555 | -- | -- |
| A-13-01 18ABB | -- | -- | X | 53 | 6 | H | 112 | 5,200 | -- | -- |
| A-13-01 18BAD1 | 01/ /72 | -- | -- | -- | 6 | -- | 305 | 5,260 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-13-01 18BAD2 | 01/ /75 | -- | -- | -- | 5 | H | 165 | 5,260 | -- | -- |
| A-13-01 18BAD3 | -- | -- | -- | -- | -- | H | -- | 5,280 | -- | -- |
| A-13-01 22AAA | -- | -- | -- | -- | -- | U | -- | 4,510 | -- | -- |
| A-13-01 22BAC | 05/27/78 | -- | P | 100 | 5.56 | -- | 220 | 4,640 | -- | -- |
| A-13-01 22CAB | 01/ /33 | -- | -- | -- | -- | H | 90 | 4,560 | -- | -- |
| A-13-01 23ABA | 02/01/74 | C | X | 18 | 8.63 | H | 175 | 4,520 | -- | -- |
| A-13-01 24BAA | 01/ /74 | -- | X | 60 | 6 | -- | 375 | 4,770 | -- | -- |
| A-13-01 28ADA | 06/ /72 | -- | -- | 178 | 5.60 | H | 220 | 4,600 | -- | -- |
| A-13-01H02AAA | -- | -- | -- | -- | -- | S | -- | 4,780 | -- | -- |
| A-13-02 08CDB | -- | -- | O | -- | 8 | H | 25 | 4,681 | -- | -- |
| A-13-02 11AAA | -- | -- | -- | -- | -- | S | -- | 4,525 | -- | -- |
| A-13-02 24ACC | -- | -- | -- | -- | -- | S | -- | 4,180 | -- | -- |
| A-13-02 26CBC | -- | -- | -- | -- | -- | S | -- | 4,202 | -- | -- |
| A-13-02 30DBD | -- | D | X | -- | 60 | S | 10 | 4,512 | -- | -- |
| A-13-02 36DDC | -- | -- | -- | -- | -- | S | 20 | 4,020 | -- | -- |
| A-13-03 01BDC | -- | -- | -- | -- | 6.50 | S | -- | 4,660 | -- | -- |
| A-13-03 07DBD | -- | -- | -- | 81 | 6.62 | S | 200 | 4,452 | -- | -- |
| A-13-03 09CBD | -- | -- | X | 249 | 6 | S | 275 | 4,377 | -- | -- |
| A-13-03 14BCA | -- | -- | -- | -- | 15 | I,S | -- | 4,440 | -- | -- |
| A-13-03 14BCD | -- | -- | -- | -- | 6 | -- | -- | 4,440 | -- | -- |
| A-13-03 26CDC | -- | -- | -- | -- | 8 | S | 73 | 4,575 | -- | -- |
| A-13-03 26CDC | -- | -- | -- | -- | -- | S | -- | 4,565 | -- | -- |
| A-13-04 18ADD | -- | -- | -- | -- | -- | S | -- | 4,680 | -- | -- |
| A-14-01 14BBB | -- | -- | -- | -- | 8 | S | 24 | 4,890 | -- | -- |
| A-14-01 16ACC | -- | C | -- | -- | 6 | -- | 237 | 4,810 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-14-01 17AAD | 11/20/76 | C | -- | 100 | 11 | -- | 1,100 | 4,778.99 | -- | -- |
| A-14-01 20CBA1 | 11/14/74 | -- | X | 53 | 8 | C | 400 | 4,885 | -- | -- |
| A-14-01 20CBA2 | 02/07/81 | -- | -- | -- | 6 | I | 315 | 4,875 | 350 | 02/07/81 |
| A-14-01 20CDD | -- | -- | -- | -- | -- | -- | -- | 4,777.62 | 408 | 05/31/78 |
| A-14-01 21CAA | 06/ /81 | -- | -- | -- | 6.62 | N | 237 | 4,740 | -- | -- |
| A-14-01 22CAD | -- | -- | -- | -- | -- | S | 750 | 4,720 | 96 | -- |
| A-14-01 22DCC | -- | D | C | -- | -- | -- | -- | 4,710 | -- | -- |
| A-14-01 24DCB | -- | -- | -- | -- | 8 | S | -- | 4,928 | -- | -- |
| A-14-01 27DBB | 03/28/67 | -- | P | -- | 8 | -- | 606 | 4,659.91 | -- | -- |
| A-14-01 28ADA1 | 1936 | C | X | 80 | 8 | U | 850 | 4,689.94 | 340W | -- |
| A-14-01 28ADA2 | 1969 | C | P | 80 | 12 | I | 534 | 4,682.98 | 940 | 04/02/70 |
| A-14-01 28BBB | -- | -- | -- | -- | -- | I | 345 | 4,714.98 | 125 | -- |
| A-14-01 28BCB | 1967 | C | X | 30 | 8 | H | 309 | 4,758.50 | 35 | -- |
| A-14-01 28CCA | 1972 | C | -- | -- | 16 | I | 638 | 4,746.60 | 776 | 05/30/74 |
| A-14-01 28CDC | 1969 | C | P | 80 | 14 | H | 582 | 4,724.49 | 900 | -- |
| A-14-01 28DAC | -- | -- | -- | -- | -- | H | 400 | 4,666.38 | 270 | -- |
| A-14-01 29AAA | -- | -- | -- | -- | -- | I | 710 | 4,726.02 | 800 | -- |
| A-14-01 34ACB | -- | -- | -- | -- | -- | -- | -- | 4,623 | -- | -- |
| A-14-01 34CAC | 06/ /69 | -- | P | 50 | 12 | I | 565 | 4,622 | -- | -- |
| A-14-01 34CDA1 | -- | -- | -- | -- | -- | I | -- | 4,620 | -- | -- |
| A-14-01 34CDA2 | -- | -- | -- | -- | -- | H | -- | 4,620 | -- | -- |
| A-14-01 34CDA3 | -- | -- | -- | -- | -- | H | -- | 4,610 | -- | -- |
| A-14-01 35DDA1 | -- | C | P | 270 | 6 | H | 320 | 4,705 | -- | -- |
| A-14-01 35DDA2 | 08/03/75 | -- | P | 190 | 6.50 | H | 348 | 4,690 | -- | -- |
| A-14-01 35DDC1 | 08/20/72 | C | P | 300 | 8 | P | 350 | 4,695 | -- | -- |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| A-14-01 35DDC2 | -- | -- | -- | -- | -- | -- | -- | 4,695 | -- | -- |
| A-14-01 35DDD | 01/ /71 | -- | P | 150 | 8 | H | 420 | 4,680 | -- | -- |
| A-14-02 07DDA | -- | -- | -- | -- | -- | S | 23 | 5,344 | -- | -- |
| A-14-02 32DCA | -- | -- | -- | -- | -- | S | -- | 4,960 | -- | -- |
| A-14-02H25CCA | -- | D | -- | -- | 54 | S | -- | 5,150 | -- | -- |
| A-15-01 01BCD | -- | -- | -- | -- | -- | U | -- | 5,620 | -- | -- |
| A-15-01 10BCD1 | -- | -- | -- | -- | 6 | -- | -- | 5,308 | -- | -- |
| A-15-01 10BCD2 | -- | -- | -- | -- | 6 | S | -- | 5,308 | -- | -- |
| A-15-01 12ACB | -- | -- | -- | -- | -- | U | -- | 5,610 | -- | -- |
| A-15-01 15CBB | -- | -- | -- | -- | -- | S | 120 | 5,230 | -- | -- |
| A-15-01 18CBD | -- | C | -- | -- | -- | H,S | -- | 4,937 | -- | -- |
| A-15-01 26ABC | -- | -- | -- | -- | -- | S | 162 | 5,339 | -- | -- |
| A-15-01 28ACC | -- | -- | X | -- | 5 | U | 378 | 5,072 | -- | -- |
| A-15-02 18DBB UN | -- | D | C | -- | 36 | H | 27 | 5,770 | -- | -- |
| A-16-01 21ACA1 | -- | -- | -- | -- | 6 | U | -- | 5,350 | -- | -- |
| A-16-01 21ACA2 | -- | -- | -- | -- | 8 | S | -- | 5,349 | -- | -- |
| A-16-01 27DA UN | -- | -- | -- | 185 | 6.25 | S | -- | 5,450 | -- | -- |
| B-12H01 20CBC | -- | -- | -- | -- | -- | H | -- | 6,565 | -- | -- |
| B-12H01 33BAB | 01/ /76 | -- | -- | -- | -- | I | -- | 6,220 | -- | -- |
| B-13-02 26ACC | -- | -- | X | 5 | 7 | H | 83 | 6,245 | -- | -- |
| B-13-02 27ADA | -- | -- | -- | -- | -- | I | 17 | 6,080 | -- | -- |
| B-14-01 02CBA | -- | -- | -- | -- | -- | -- | -- | 4,958 | -- | -- |
| B-14-01 06ADD | -- | -- | -- | -- | 6 | H | 839 | 5,203 | -- | -- |
| B-14-01 06BCB | 1972 | -- | -- | -- | 6 | H | 602 | 5,030 | -- | -- |
| B-14-01 10ACD | 1972 | C | -- | 805 | 14 | -- | 750 | 5,034.83 | 1,750 | 11/09/72 |

Table 5.--Records of selected wells in the northern part of the Agua Fria area—Continued

| Local number | Date completed | Method | Finish | Depth to first opening (feet) | Casing diameter (inches) | Use of water | Depth of well (feet) | Altitude of land surface (feet) | Discharge (gallons per minute) | Date discharge measured |
|---|---|---|---|---|---|---|---|---|---|---|
| B-14-01 11ACB | -- | -- | -- | -- | -- | -- | 885 | 5,043.72 | 200 | 02/26/74 |
| B-14-01 11DAA | 04/12/73 | C | P | 496 | 16 | -- | 500 | 5,043.52 | 200 | 09/17/73 |
| B-14-01 14ACC | 1964 | C | X | 30 | 16 | H | 496 | 5,111.16 | 260 | 10/23/64 |
| B-14-01 15ABA | 1971 | C | P | 400 | 12 | H | 996 | 5,117.42 | 440 | -- |
| B-14-01 18ACA | 1957 | C | P | 150 | 6 | H | 265 | 5,260 | -- | -- |
| B-14-01 21ADA | -- | -- | -- | -- | -- | -- | -- | 5,255 | -- | -- |
| B-14-01 22AAC | 1971 | C | P | 360 | 10 | H | 655 | 5,240 | 370 | -- |
| B-14-01 22ADA | 1971 | C | P | 310 | 14 | -- | 612 | 5,184.10 | -- | -- |
| B-14-01 22BDC | 1971 | C | P | 250 | 12 | -- | 670 | 5,221.44 | -- | -- |
| B-14-01 24DCC | 10/09/73 | C | P | 246 | 6 | H,S | 346 | 5,080 | -- | -- |
| B-14-01 25DAC | 06/21/55 | C | -- | 120 | 8 | -- | 121 | 4,933 | -- | -- |
| B-14-01 26AAA | 09/01/72 | C | X | 0 | -- | -- | 357 | 5,120 | -- | -- |
| B-14-01 26CCD | -- | -- | -- | -- | -- | -- | -- | 5,180 | -- | -- |
| B-14-01 27DCC | -- | -- | -- | -- | -- | -- | -- | 5,265 | -- | -- |
| B-14-01 28CBA | -- | -- | -- | -- | -- | P | -- | 5,265 | -- | -- |
| B-14-01 31BBC | -- | -- | -- | -- | 6 | S | -- | 5,585 | -- | -- |

Table 6.--Chemical analysis of water from the northern part

Local identifier: See figure 2 for description of well-numbering and location system; UN, unsurveyed.

Site: SP, spring; GW, ground water; SW, surface water.

| Local identifier | Date of sample | Site | Streamflow, instantaneous ($ft^3/s$) | Specific conductance (µS/cm) | Temperature (°C) | pH (units) | Solids, residue at 180°C dissolved (mg/L) | Solids, sum of constituents, dissolved (mg/L) | Hardness (mg/L as $CACO_3$) |
|---|---|---|---|---|---|---|---|---|---|
| Agua Fria River (Site 1) | 80-11-21 | SW | 1.6 | 486 | 15.3 | 8.8 | 306 | 311 | 210 |
| Agua Fria River | 78-10-05 | SW | ---- | 530 | 20.0 | --- | --- | --- | --- |
| Agua Fria River (Site 3A) | 80-11-22 | SW | ---- | 955 | 8.3 | 8.4 | 582 | 581 | 380 |
| Agua Fria River (Site 3) | 81-06-03 | SW | .22 | 975 | 22.0 | 7.9 | --- | --- | --- |
| Agua Fria River (Site 4) | 81-06-03 | SW | .55 | 1,083 | 18.0 | 7.6 | --- | --- | --- |
| Agua Fria River (Site 5) | 80-11-23 | SW | 1.2 | 1,211 | 10.3 | 8.5 | 748 | 706 | 480 |
| Agua Fria River | 80-11-24 | SW | ---- | 974 | 13.3 | 8.2 | --- | --- | --- |
| | 81-06-04 | SW | ---- | 1,079 | 23.9 | 8.1 | --- | --- | --- |
| Agua Fria River (Site 6) | 80-11-24 | SW | 3.8 | 858 | 12.5 | 8.2 | --- | --- | --- |
| | 81-06-04 | SW | 1.2 | 994 | 24.5 | 8.1 | --- | --- | --- |
| Agua Fria River (Site 7) | 80-11-25 | SW | 4.9 | 885 | 12.7 | 8.6 | 509 | 519 | 340 |
| Agua Fria River (Site 8) | 80-12-12 | SW | 6.5 | ----- | 10.0 | 8.8 | 540 | 523 | 340 |
| Little Ash Creek (Site 9) | 81-06-04 | SW | .30 | 489 | 24.8 | 8.1 | --- | --- | --- |
| Ash Creek (Site 10) | 80-11-23 | SW | .98 | 660 | 12.2 | 8.5 | 394 | 393 | 270 |
| Sycamore Creek (Site 12) | 80-12-13 | SW | .31 | ----- | 10.0 | 8.0 | --- | 290 | 230 |
| Sycamore Creek | 81-06-05 | SW | .28 | 500 | 27.4 | 8.3 | --- | --- | --- |
| Little Sycamore Creek | 81-06-05 | SW | .15 | 567 | 24.8 | 8.2 | --- | --- | --- |
| Sycamore Creek (Site 16) | 80-11-24 | SW | 1.1 | 611 | 10.5 | 8.3 | 366 | 379 | 280 |
| Big Bug Creek | 78-10-17 | SW | ---- | 480 | 13.0 | --- | --- | --- | --- |
| | 78-10-17 | SW | ---- | 480 | 13.0 | --- | --- | --- | --- |
| Big Bug Creek (Site 17) | 80-11-25 | SW | .60 | 836 | 7.9 | 8.5 | --- | --- | --- |
| | 81-06-01 | SW | .28 | 722 | 23.2 | 8.1 | --- | --- | --- |
| A-10-02 02DDD | 78-05-19 | SP | ---- | 690 | ---- | --- | --- | --- | --- |
| A-10-03 08DAA | 78-05-18 | GW | ---- | 720 | ---- | --- | --- | --- | --- |
| A-11-02 05BAA | 77-06-10 | GW | ---- | 540 | ---- | --- | --- | --- | --- |

Abbreviations: $ft^3/s$, cubic feet per second; µS/cm, microsiemens per centimeter at 25°C Celsius; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; ----, no data; 0, concentration of constituent is less than the detection limit of analysis method; <, concentration of constituent is less than the value shown.

| Date of sample | Hardness, noncarbonate (mg/L $CACO_3$) | Hardness noncarbonate (mg/L as $CACO_3$) | Sodium adsorption ratio | Alkalinity field (mg/L as $CACO_3$) | Alkalinity lab (mg/L as $CACO_3$) | Bicarbonate it-fld (mg/L as $HCO_3$) | Bicarbonate fet-fld (mg/L as $HCO_3$) | Carbonate fet-fld (mg/L as $CO_3$) | Chloride, dissolved (mg/L as CL) |
|---|---|---|---|---|---|---|---|---|---|
| 80-11-21 | 40 | ----- | 0.7 | --- | 170 | --- | --- | --- | 19 |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 80-11-22 | 220 | ----- | 1.1 | --- | 160 | --- | --- | --- | 110 |
| 81-06-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-06-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 80-11-23 | 230 | ----- | 1.4 | --- | 250 | --- | --- | --- | 100 |
| 80-11-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-06-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 80-11-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-06-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 80-11-25 | 69 | ----- | 1.1 | --- | 270 | --- | --- | --- | 56 |
| 80-12-12 | 88 | ----- | 1.2 | --- | 250 | --- | --- | --- | 59 |
| 81-06-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 80-11-23 | 3 | ----- | .9 | --- | 270 | --- | --- | --- | 30 |
| 80-12-13 | 2 | ----- | .2 | --- | 230 | --- | --- | --- | 3.7 |
| 81-06-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-06-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 80-11-24 | 0 | ----- | .7 | --- | 290 | --- | --- | --- | 27 |
| 78-10-17 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-17 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 80-11-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-06-01 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-05-19 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-05-18 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-06-10 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Calcium dis-solved (mg/L as CA) | Magne-sium, dis-solved (mg/L as MG) | Potas-sium, dis-solved (mg/L as K) | Sodium+ potas-sium, dis-solved (mg/L as NA) | Sodium, dis-solved (mg/L as NA) | Sulfate dis-solved (mg/L (as $SO_4$) | Fluo-ride, dis-solved (mg/L as F) | Silica, dis-solved (mg/L as $SIO_2$) |
|---|---|---|---|---|---|---|---|---|---|
| Agua Fria River (Site 1) | 80-11-21 | 61 | 14 | 1.4 | --- | 23 | 54 | 0.3 | 19 |
| Agua Fria River | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| Agua Fria River (Site 3A) | 80-11-22 | 110 | 26 | 2.7 | --- | 48 | 170 | .4 | 13 |
| Agua Fria River (Site 3) | 81-06-03 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| Agua Fria River (Site 4) | 81-06-03 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| Agua Fria River (Site 5) | 80-11-23 | 120 | 43 | 1.6 | --- | 69 | 190 | .4 | 27 |
| Agua Fria River | 80-11-24 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| | 81-06-04 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| Agua Fria River (Site 6) | 80-11-24 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| | 81-06-04 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| Agua Fria River (Site 7) | 80-11-25 | 78 | 35 | 2.3 | --- | 47 | 110 | .3 | 28 |
| Agua Fria River (Site 8) | 80-12-12 | 76 | 36 | 2.1 | --- | 51 | 120 | .3 | 27 |
| Little Ash Creek (Site 9) | 81-06-04 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| Ash Creek (Site 10) | 80-11-23 | 60 | 30 | 2.4 | --- | 36 | 45 | .2 | 26 |
| Sycamore Creek (Site 12) | 80-12-13 | 50 | 26 | 1.4 | --- | 7.5 | 7.1 | .1 | 55 |
| Sycamore Creek | 81-06-05 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| Little Sycamore Creek | 81-06-05 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| Sycamore Creek (Site 16) | 80-11-24 | 54 | 34 | 1.6 | --- | 28 | 22 | .4 | 37 |
| Big Bug Creek | 78-10-17 | ----- | ---- | ----- | --- | ----- | ----- | .7 | ---- |
| | 78-10-17 | ----- | ---- | ----- | --- | ----- | ----- | .7 | ---- |
| Big Bug Creek (Site 17) | 80-11-25 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| | 81-06-01 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| A-10-02 02DDD | 78-05-19 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-10-03 08DAA | 78-05-18 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-11-02 05BAA | 77-06-10 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |

selected wells, springs, and base flow sites in Agua Fria area--Continued

| Date of sample | Nitrogen, NO2+NO3 dissolved (mg/L as N) | Phosphorus, ortho, dissolved (mg/L as P) | Aluminum, dissolved (µg/L as AL) | Antimony, dissolved (µg/L as SB) | Arsenic dissolved (µg/L as AS) | Barium, dissolved (µg/L as BA) | Beryllium, dissolved (µg/L (as BE) | Boron, dissolved (µg/L as B) | Cadmium, dissolved (µg/L as CD) |
|---|---|---|---|---|---|---|---|---|---|
| 80-11-21 | 3.6 | 0.020 | 20 | 0 | 4 | 80 | <1 | 220 | <1 |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 80-11-22 | .91 | .010 | 10 | 0 | 4 | 70 | <1 | 70 | <1 |
| 81-06-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-06-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 80-11-23 | .99 | .060 | -- | --- | --- | ---- | -- | 100 | --- |
| 80-11-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-06-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 80-11-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-06-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 80-11-25 | .00 | .060 | -- | --- | --- | ---- | -- | 90 | --- |
| 80-12-12 | .36 | .100 | -- | --- | 11 | ---- | -- | 60 | --- |
| 81-06-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 80-11-23 | .27 | .010 | -- | --- | 5 | ---- | -- | 40 | --- |
| 80-12-13 | .08 | .070 | 30 | --- | 2 | 30 | <1 | 0 | <1 |
| 81-06-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-06-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 80-11-24 | .06 | .050 | 10 | 0 | 5 | 30 | <1 | 50 | <1 |
| 78-10-17 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-17 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 80-11-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-06-01 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-05-19 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-05-18 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-06-10 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Chromium, dissolved (µg/L as CR) | Chromium, hexavalent, dissolved (µg/L as CR) | Cobalt, dissolved (µg/L as CO) | Copper, dissolved (µg/L as CU) | Iron, dissolved (µg/L as FE) | Lead, dissolved (µg/L as PB) | Lithium, dissolved (µg/L as LI) | Manganese, dissolved (µg/L as MG) |
|---|---|---|---|---|---|---|---|---|---|
| Agua Fria River (Site 1) | 80-11-21 | 0 | -- | <3 | 1 | 10 | 0 | 8 | 2 |
| Agua Fria River | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| Agua Fria River (Site 3A) | 80-11-22 | 0 | -- | <3 | 3 | <10 | 0 | 8 | 6 |
| Agua Fria River (Site 3) | 81-06-03 | --- | -- | -- | --- | --- | --- | -- | --- |
| Agua Fria River (Site 4) | 81-06-03 | --- | -- | -- | --- | --- | --- | -- | --- |
| Agua Fria River (Site 5) | 80-11-23 | --- | -- | -- | --- | 10 | --- | -- | --- |
| Agua Fria River | 80-11-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-06-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| Agua Fria River (Site 6) | 80-11-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-06-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| Agua Fria River (Site 7) | 80-11-25 | --- | -- | -- | --- | <10 | --- | -- | --- |
| Agua Fria River (Site 8) | 80-12-12 | --- | 0 | -- | --- | <10 | --- | -- | --- |
| Little Ash Creek (Site 9) | 81-06-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| Ash Creek (Site 10) | 80-11-23 | --- | -- | -- | --- | 10 | --- | -- | --- |
| Sycamore Creek (Site 12) | 80-12-13 | --- | 0 | <3 | <10 | <10 | 63 | <4 | 2 |
| Sycamore Creek | 81-06-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| Little Sycamore Creek | 81-06-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| Sycamore Creek (Site 16) | 80-11-24 | 10 | -- | <3 | 0 | <10 | 0 | <4 | 7 |
| Big Bug Creek | 78-10-17 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 78-10-17 | --- | -- | -- | --- | --- | --- | -- | --- |
| Big Bug Creek (Site 17) | 80-11-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-06-01 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-10-02 02DDD | 78-05-19 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-10-03 08DAA | 78-05-18 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 05BAA | 77-06-10 | --- | -- | -- | --- | --- | --- | -- | --- |

| Date of sample | Mercury, dis-solved (µg/L as HG) | Molyb-denum, dis-solved (µg/L as MO) | Nickel, dis-solved (µg/L as NI) | Sele-nium, dis-solved (µg/L as SE) | Silver, dis-solved (µg/L as AG) | Stron-tium, dis-solved (µg/L as SR) | Vana-dium, dis-solved (µg/L as V) | Zinc, dis-solved (µg/L (as ZN) | Cyanide total (mg/L as CN) |
|---|---|---|---|---|---|---|---|---|---|
| 80-11-21 | 0.0 | <10 | 0 | 2 | 0 | 350 | <6.0 | 7 | 0.00 |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-11-22 | .0 | <10 | 0 | 5 | 0 | 570 | <6.0 | 6 | .00 |
| 81-06-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-06-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-11-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | .00 |
| 80-11-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-06-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-11-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-06-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-11-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-12-12 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-06-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-11-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-12-13 | .0 | <10 | --- | 0 | --- | 270 | <6.0 | <3 | ---- |
| 81-06-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-06-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-11-24 | .0 | <10 | 0 | 0 | 0 | 490 | 5.0 | <3 | .00 |
| 78-10-17 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-17 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-11-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-06-01 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-05-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-05-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-06-10 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Site | Streamflow, instantaneous ($ft^3/s$) | Specific conductance ($\mu S/cm$) | Temperature (°C) | pH (units) | Solids, residue at 180°C dissolved (mg/L) | Solids, sum of constituents, dissolved (mg/L) | Hardness (mg/L as $CACO_3$) |
|---|---|---|---|---|---|---|---|---|---|
| A-11-02 06ABA | 77-06-10 | GW | ---- | 560 | ---- | --- | --- | --- | --- |
| A-11-02 11CCA | 77-06-09 | GW | ---- | 410 | ---- | --- | --- | --- | --- |
| A-11-02 09CCC | 76-06-02 | GW | ---- | 555 | ---- | 7.7 | 380 | --- | 234 |
| A-11-02 09CCD | 69-07-25 | GW | ---- | 526 | ---- | 7.8 | --- | 340 | 244 |
| A-11-02 12BDA | 77-05-24 | GW | ---- | 1,300 | ---- | --- | --- | --- | --- |
| A-11-02 12DDA | 77-05-24 | GW | ---- | 1,300 | ---- | --- | --- | --- | --- |
| A-11-02 14ADB | 77-06-09 | GW | ---- | 490 | ---- | --- | --- | --- | --- |
| A-11-02 14BAC | 77-06-09 | GW | ---- | 420 | ---- | --- | --- | --- | --- |
| A-11-02 14CAA | 79-06-21 | GW | ---- | 545 | ---- | 7.2 | --- | 336 | 240 |
| A-11-02 14CBB1 | 77-06-10 | GW | ---- | 490 | 23.0 | --- | --- | --- | --- |
| A-11-02 14CCA | 77-05-25 | GW | ---- | 250 | ---- | --- | --- | --- | --- |
| A-11-02 14CCD1 | 77-05-25 | GW | ---- | 620 | ---- | --- | --- | --- | --- |
| A-11-02 14CCD2 | 77-05-25 | GW | ---- | 530 | ---- | --- | --- | --- | --- |
| A-11-02 14DAC | 77-05-24 | GW | ---- | 510 | ---- | --- | --- | --- | --- |
| A-11-02 14DAD | 77-05-24 | GW | ---- | 290 | ---- | --- | --- | --- | --- |
| A-11-02 14DCD1 | 78-08-23 | GW | ---- | 520 | ---- | --- | --- | --- | --- |
| A-11-02 15ADB | 77-06-09 | GW | ---- | 440 | 26.0 | --- | --- | --- | --- |
| A-11-02 25BDD | 77-06-09 | GW | ---- | 490 | ---- | --- | --- | --- | --- |
| | 79-06-21 | GW | ---- | 640 | ---- | 7.1 | --- | 405 | 290 |
| A-11-02 29DAA | 78-10-20 | GW | ---- | 640 | 19.0 | --- | --- | --- | --- |
| A-11-03 18ADA | 79-07-05 | GW | ---- | 785 | 21.0 | 7.4 | --- | 531 | 160 |
| A-11-04 1CCDC | 80-11-00 | SP | ---- | --- | 12.0 | 8.1 | --- | 375 | 310 |
| A-12-01 02AAD | 78-10-19 | SP | ---- | 860 | ---- | --- | --- | --- | --- |
| A-12-01 04BDA | 77-08-03 | GW | ---- | 1,000 | 21.0 | --- | --- | --- | --- |
| A-12-01 04CAA1 | 79-07-05 | GW | ---- | 1,080 | ---- | 7.2 | --- | 699 | 520 |
| A-12-01 05CAA2 | 78-10-17 | GW | ---- | 650 | ---- | --- | --- | --- | --- |
| A-12-01 05CAB | 78-10-17 | GW | ---- | 870 | 17.0 | --- | --- | --- | --- |
| A-12-01 09BCB | 78-10-20 | GW | ---- | 485 | ---- | --- | --- | --- | --- |
| A-12-01 15CDB | 77-07-23 | GW | ---- | 1,100 | 21.0 | --- | --- | --- | --- |
| A-12-01 22BBB2 | 78-10-04 | GW | ---- | 740 | 18.0 | --- | --- | --- | --- |
| A-12-01 22BCD | 78-10-04 | GW | ---- | 800 | ---- | --- | --- | --- | --- |
| A-12-01 22CAB | 78-10-04 | GW | ---- | 855 | 17.0 | --- | --- | --- | --- |
| A-12-01 22CDA | 78-10-03 | GW | ---- | 1,420 | 19.0 | --- | --- | --- | --- |
| | 79-07-06 | GW | ---- | 1,220 | ---- | 7.3 | --- | 698 | 400 |
| A-12-01 22DDD | 78-10-04 | GW | ---- | 1,150 | 17.0 | --- | --- | --- | --- |
| A-12-01 23BBA | 78-10-18 | SP | ---- | 1,465 | 15.5 | --- | --- | --- | --- |
| A-12-01 24CDC | 78-10-19 | GW | ---- | 580 | 23.0 | --- | --- | --- | --- |
| A-12-01 26BAA1 | 77-07-23 | GW | ---- | 1,000 | ---- | --- | --- | --- | --- |
| A-12-01 26BAA2 | 77-07-23 | GW | ---- | 370 | ---- | --- | --- | --- | --- |
| A-12-01 26BAA3 | 77-07-23 | GW | ---- | 860 | 17.0 | --- | --- | --- | --- |
| A-12-01 26BAB | 78-10-03 | GW | ---- | 790 | 18.0 | --- | --- | --- | --- |
| A-12-01 26BBB | 78-10-03 | GW | ---- | 2,130 | ---- | --- | --- | --- | --- |
| A-12-01 26DAB | 78-10-20 | GW | ---- | 700 | ---- | --- | --- | --- | --- |
| A-12-01 26DDD | 77-07-23 | GW | ---- | 500 | 20.0 | --- | --- | --- | --- |
| A-12-01 27DBA1 | 78-10-03 | GW | ---- | 2,600 | 18.0 | --- | --- | --- | --- |

selected wells, springs, and base flow sites in Agua Fria area--Continued

| Date of sample | Hardness, noncarbonate (mg/L $CACO_3$) | Hardness noncarbonate (mg/L as $CACO_3$) | Sodium adsorption ratio | Alkalinity field (mg/L as $CACO_3$) | Alkalinity lab (mg/L as $CACO_3$) | Bicarbonate it-fld (mg/L as $HCO_3$) | Bicarbonate fet-fld (mg/L as $HCO_3$) | Carbonate fet-fld (mg/L as $CO_3$) | Chloride, dissolved (mg/L as CL) |
|---|---|---|---|---|---|---|---|---|---|
| 77-06-10 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-06-09 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 76-06-02 | --- | ----- | 1.1 | 216 | --- | --- | --- | --- | 21 |
| 69-07-25 | --- | ----- | --- | --- | --- | --- | 208 | 0 | 24 |
| 77-05-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-05-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-06-09 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-06-09 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-06-21 | 54 | ----- | .4 | 190 | --- | --- | 230 | 0 | 39 |
| 77-06-10 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-05-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-05-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-05-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-05-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-05-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-06-09 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-06-09 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-06-21 | 64 | ----- | .6 | 230 | --- | --- | 280 | 0 | 45 |
| 78-10-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-07-05 | 0 | ----- | 4.1 | 340 | --- | --- | 420 | 0 | 34 |
| 80-11-00 | 49 | ----- | .5 | --- | 260 | --- | --- | --- | 14 |
| 78-10-19 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-08-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-07-05 | 210 | ----- | .6 | 310 | --- | --- | 380 | 0 | 85 |
| 78-10-17 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-17 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-07-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-07-06 | 210 | ----- | 2.1 | 190 | --- | --- | 230 | 0 | 180 |
| 78-10-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-18 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-19 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-07-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-07-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-07-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-07-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Calcium dis- solved (mg/L as CA) | Magne- sium, dis- solved (mg/L as MG) | Potas- sium, dis- solved (mg/L as K) | Sodium+ potas- sium, dis- solved (mg/L as NA) | Sodium, dis- solved (mg/L as NA) | Sulfate dis- solved (mg/L (as $SO_4$) | Fluo- ride, dis- solved (mg/L as F) | Silica, dis- solved (mg/L as $SIO_2$) |
|---|---|---|---|---|---|---|---|---|---|
| A-11-02 06ABA | 77-06-10 | ----- | ---- | ----- | --- | ----- | ----- | <0.1 | ---- |
| A-11-02 11CCA | 77-06-09 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| A-11-02 09CCC | 76-06-02 | 58 | 25 | ----- | --- | 39 | 60 | .2 | ---- |
| A-11-02 09CCD | 69-07-25 | 63 | 20 | ----- | 18 | ----- | 68 | .4 | ---- |
| A-11-02 12BDA | 77-05-24 | ----- | ---- | ----- | --- | ----- | ----- | 1.3 | ---- |
| A-11-02 12DDA | 77-05-24 | ----- | ---- | ----- | --- | ----- | ----- | 1.4 | ---- |
| A-11-02 14ADB | 77-06-09 | ----- | ---- | ----- | --- | ----- | ----- | <.1 | ---- |
| A-11-02 14BAC | 77-06-09 | ----- | ---- | ----- | --- | ----- | ----- | 1.0 | ---- |
| A-11-02 14CAA | 79-06-21 | 74 | 14 | 1.8 | 18 | 16 | 27 | .4 | 34 |
| A-11-02 14CBB1 | 77-06-10 | ----- | ---- | ----- | --- | ----- | ----- | .9 | ---- |
| A-11-02 14CCA | 77-05-25 | ----- | ---- | ----- | --- | ----- | ----- | 1.0 | ---- |
| A-11-02 14CCD1 | 77-05-25 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-11-02 14CCD2 | 77-05-25 | ----- | ---- | ----- | --- | ----- | ----- | .1 | ---- |
| A-11-02 14DAC | 77-05-24 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-11-02 14DAD | 77-05-24 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| A-11-02 14DCD1 | 78-08-23 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-11-02 15ADB | 77-06-09 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| A-11-02 25BDD | 77-06-09 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| | 79-06-21 | 88 | 18 | 1.7 | 26 | 24 | 50 | .5 | 35 |
| A-11-02-29DAA | 78-10-20 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-11-03 18ADA | 79-07-05 | 34 | 19 | 6.9 | 130 | 120 | 40 | .4 | 64 |
| A-11-04 1CCDC | 80-11-00 | 66 | 35 | 1.0 | --- | 19 | 15 | .7 | 66 |
| A-12-01 02AAD | 78-10-19 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-12-01 04BDA | 77-08-03 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-12-01 04CAA1 | 79-07-05 | 160 | 29 | 1.0 | 32 | 31 | 160 | .3 | 33 |
| A-12-01 05CAA2 | 78-10-17 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-12-01 05CAB | 78-10-17 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-12-01 09BCB | 78-10-20 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-12-01 15CDB | 77-07-23 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| A-12-01 22BBB2 | 78-10-04 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-12-01 22BCD | 78-10-04 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-12-01 22CAB | 78-10-04 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-12-01 22CDA | 78-10-03 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| | 79-07-06 | 120 | 25 | 4.3 | 99 | 95 | 150 | .2 | 9.9 |
| A-12-01 22DDD | 78-10-04 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-12-01 23BBA | 78-10-18 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| A-12-01 24CDC | 78-10-19 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-12-01 26BAA1 | 77-07-23 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| A-12-01 26BAA2 | 77-07-23 | ----- | ---- | ----- | --- | ----- | ----- | .7 | ---- |
| A-12-01 26BAA3 | 77-07-23 | ----- | ---- | ----- | --- | ----- | ----- | .7 | ---- |
| A-12-01 26BAB | 78-10-03 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-12-01 26BBB | 78-10-03 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-12-01 26DAB | 78-10-20 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-12-01 26DDD | 77-07-23 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-12-01 27DBA1 | 78-10-03 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |

selected wells, springs, and base flow sites in Agua Fria area--Continued

| Date of sample | Nitrogen, NO2+NO3 dissolved (mg/L as N) | Phosphorus, ortho, dissolved (mg/L as P) | Aluminum, dissolved (µg/L as AL) | Antimony, dissolved (µg/L as SB) | Arsenic dissolved (µg/L as AS) | Barium, dissolved (µg/L as BA) | Beryllium, dissolved (µg/L (as BE) | Boron, dissolved (µg/L as B) | Cadmium, dissolved (µg/L as CD) |
|---|---|---|---|---|---|---|---|---|---|
| 77-06-10 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-06-09 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 76-06-02 | ----- | ----- | -- | --- | <10 | ---- | -- | --- | <10 |
| 69-07-25 | ----- | ----- | -- | --- | <10 | ---- | -- | --- | --- |
| 77-05-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-05-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-05-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-05-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-06-21 | 3.8 | ----- | -- | --- | --- | ---- | -- | 30 | --- |
| 77-06-10 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-05-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-05-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-05-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-05-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-05-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-06-09 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-06-09 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-06-21 | 1.1 | ----- | -- | --- | --- | ---- | -- | 50 | --- |
| 78-10-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-07-05 | 1.2 | ----- | -- | --- | --- | ---- | -- | 520 | --- |
| 80-11-00 | .32 | ----- | 10 | --- | 2 | 60 | <1 | 40 | <1 |
| 78-10-19 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-08-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-07-05 | 2.8 | ----- | -- | --- | --- | ---- | -- | 180 | --- |
| 78-10-17 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-17 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-07-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-07-06 | .08 | ----- | -- | --- | --- | ---- | -- | 100 | --- |
| 78-10-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-18 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-19 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-07-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-07-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-07-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-07-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Chromium, dissolved (µg/L as CR) | Chromium, hexavalent, dissolved (µg/L as CR) | Cobalt, dissolved (µg/L as CO) | Copper, dissolved (µg/L as CU) | Iron, dissolved (µg/L as FE) | Lead, dissolved (µg/L as PB) | Lithium, dissolved (µg/L as LI) | Manganese, dissolved (µg/L as HG) |
|---|---|---|---|---|---|---|---|---|---|
| A-11-02 06ABA | 77-06-10 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 11CCA | 77-06-09 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 09CCC | 76-06-02 | <10 | -- | -- | <50 | 60 | <50 | -- | <50 |
| A-11-02 09CCD | 69-07-25 | <10 | -- | -- | --- | <50 | --- | -- | --- |
| A-11-02 12BDA | 77-05-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 12DDA | 77-05-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 14ADB | 77-06-09 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 14BAC | 77-06-09 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 14CAA | 79-06-21 | --- | -- | -- | --- | --- | <10 | -- | 8 |
| A-11-02 14CBB1 | 77-06-10 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 14CCA | 77-05-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 14CCD1 | 77-05-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 14CCD2 | 77-05-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 14DAC | 77-05-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 14DAD | 77-05-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 14DCD1 | 78-08-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 15ADB | 77-06-09 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-02 25BDD | 77-06-09 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 79-06-21 | --- | -- | -- | --- | <10 | --- | -- | 2 |
| A-11-02-29DAA | 78-10-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-11-03 18ADA | 79-07-05 | --- | -- | -- | --- | <10 | --- | -- | 2 |
| A-11-04 1CCDC | 80-11-00 | --- | 0 | <3 | <10 | <10 | 44 | <4 | 3 |
| A-12-01 02AAD | 78-10-19 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 04BDA | 77-08-03 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 04CAA1 | 79-07-05 | --- | -- | -- | --- | <10 | --- | -- | 20 |
| A-12-01 05CAA2 | 78-10-17 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 05CAB | 78-10-17 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 09BCB | 78-10-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 15CDB | 77-07-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 22BBB2 | 78-10-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 22BCD | 78-10-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 22CAB | 78-10-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 22CDA | 78-10-03 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 79-07-06 | --- | -- | -- | --- | <10 | --- | -- | 320 |
| A-12-01 22DDD | 78-10-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 23BBA | 78-10-18 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 24CDC | 78-10-19 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 26BAA1 | 77-07-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 26BAA2 | 77-07-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 26BAA3 | 77-07-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 26BAB | 78-10-03 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 26BBB | 78-10-03 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 26DAB | 78-10-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 26DDD | 77-07-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 27DBA1 | 78-10-03 | --- | -- | -- | --- | --- | --- | -- | --- |

| Date of sample | Mercury, dis-solved (µg/L as HG) | Molyb-denum, dis-solved (µg/L as MO) | Nickel, dis-solved (µg/L as NI) | Sele-nium, dis-solved (µg/L as SE) | Silver, dis-solved (µg/L as AG) | Stron-tium, dis-solved (µg/L as SR) | Vana-dium, dis-solved (µg/L as V) | Zinc, dis-solved (µg/L (as ZN) | Cyanide total (mg/L as CN) |
|---|---|---|---|---|---|---|---|---|---|
| 77-06-10 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-06-09 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 76-06-02 | <5.0 | --- | --- | <10 | <10 | --- | ---- | 120 | ---- |
| 69-07-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-05-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-05-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-06-09 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-06-09 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 79-06-21 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-06-10 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-05-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-05-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-05-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-05-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-05-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-06-09 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-06-09 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 79-06-21 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 79-07-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-11-00 | .0 | <10 | --- | 0 | --- | 410 | <6.0 | <3 | ---- |
| 78-10-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-08-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 79-07-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-17 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-17 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-07-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 79-07-06 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-07-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-07-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-07-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-07-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Site | Streamflow, instantaneous ($ft^3/s$) | Specific conductance (µS/cm) | Temperature (°C) | pH (units) | Solids, residue at 180°C dissolved (mg/L) | Solids, sum of constituents, dissolved (mg/L) | Hardness (mg/L as $CACO_3$) |
|---|---|---|---|---|---|---|---|---|---|
| A-12-01 27DBA2 | 78-10-03 | GW | ---- | 1,430 | 17.0 | --- | --- | --- | --- |
| A-12-01 29DAC | 78-10-05 | GW | ---- | 1,200 | 17.0 | --- | --- | --- | --- |
| A-12-01 31BCC | 78-10-05 | GW | ---- | 750 | 22.0 | --- | --- | --- | --- |
| A-12-01 33AAD | 78-10-05 | GW | ---- | 1,180 | ---- | --- | --- | --- | --- |
| A-12-01 33ADA | 78-10-05 | GW | ---- | 835 | ---- | --- | --- | --- | --- |
| A-12-01 33ADB | 78-10-05 | GW | ---- | 700 | 24.0 | --- | --- | --- | --- |
| A-12-01 34DAC1 | 78-10-05 | GW | ---- | 675 | ---- | --- | --- | --- | --- |
| A-12-01 34DBB | 78-10-05 | GW | ---- | 825 | ---- | --- | --- | --- | --- |
| A-12-02 08DBA | 78-10-18 | GW | ---- | 1,000 | 15.0 | --- | --- | --- | --- |
| | 79-07-05 | GW | ---- | 950 | 14.5 | 7.1 | --- | 620 | 420 |
| A-12-02 22BCD | 78-10-19 | GW | ---- | 1,200 | ---- | --- | --- | --- | --- |
| A-12-02 22CDC | 78-10-19 | GW | ---- | 1,050 | ---- | --- | --- | --- | --- |
| A-12-02 27ACB | 79-03-20 | GW | ---- | 1,530 | 15.0 | --- | --- | --- | --- |
| A-12-02 27BDA1 | 78-10-18 | GW | ---- | 1,150 | 16.5 | --- | --- | --- | --- |
| A-12-02 27BDA3 | 78-10-18 | GW | ---- | 1,230 | 17.5 | --- | --- | --- | --- |
| A-12-02 27DDB | 78-10-18 | GW | ---- | 820 | ---- | --- | --- | --- | --- |
| A-12-02 29ACD | 78-10-19 | GW | ---- | 800 | 22.0 | --- | --- | --- | --- |
| A-12-02 31BDD | 77-08-03 | GW | ---- | 800 | 18.0 | --- | --- | --- | --- |
| A-12-03 01CAC | 78-09-05 | SP | ---- | 615 | ---- | --- | --- | --- | --- |
| A-12-03 08BDD | 79-06-21 | GW | ---- | 645 | 17.0 | 7.3 | --- | 378 | 280 |
| A-12-03 10BAB | 78-10-05 | GW | ---- | 410 | ---- | --- | --- | --- | --- |
| A-12-03 11BBC | 78-08-31 | GW | ---- | 440 | ---- | --- | --- | --- | --- |
| A-12-03 17CCB | 78-08-31 | GW | ---- | 730 | 16.0 | --- | --- | --- | --- |
| A-12-03 20BCD | 78-08-31 | GW | ---- | 730 | 17.0 | --- | --- | --- | --- |
| A-12-03 22BBC | 78-08-31 | GW | ---- | 415 | 21.0 | --- | --- | --- | --- |
| A-12-03 28DBA | 78-08-31 | SP | ---- | 510 | 29.0 | --- | --- | --- | --- |
| A-12-03 35BAA | 78-08-31 | SP | ---- | 460 | 24.0 | --- | --- | --- | --- |
| A-13-01 02DCA | 78-09-14 | GW | ---- | 385 | 19.8 | --- | --- | --- | --- |
| A-13-01 03ABB | 78-09-20 | GW | ---- | 405 | ---- | --- | --- | --- | --- |
| A-13-01 03ACD | 78-09-20 | GW | ---- | 490 | ---- | --- | --- | --- | --- |
| A-13-01 03BBC | 78-09-13 | GW | ---- | 470 | ---- | --- | --- | --- | --- |
| A-13-01 03BCD | 78-08-23 | GW | ---- | 410 | ---- | --- | --- | --- | --- |
| A-13-01 03CAA | 78-08-23 | GW | ---- | 370 | ---- | --- | --- | --- | --- |
| A-13-01 03CBA | 78-08-23 | GW | ---- | 280 | ---- | --- | --- | --- | --- |
| A-13-01 03DAC | 78-09-20 | GW | ---- | 410 | ---- | --- | --- | --- | --- |
| A-13-01 04ABA2 | 78-09-13 | GW | ---- | 390 | ---- | --- | --- | --- | --- |
| A-13-01 04BCB | 78-09-11 | GW | ---- | 455 | ---- | --- | --- | --- | --- |
| A-13-01 05CAB2 | 78-08-24 | GW | ---- | 430 | ---- | --- | --- | --- | --- |
| A-13-01 05CBA | 78-08-31 | GW | ---- | 465 | ---- | --- | --- | --- | --- |
| A-13-01 05DCC1 | 78-08-24 | GW | ---- | 390 | ---- | --- | --- | --- | --- |
| A-13-01 05DCC2 | 78-08-24 | GW | ---- | 355 | ---- | --- | --- | --- | --- |
| A-13-01 05DDA1 | 78-08-24 | GW | ---- | 435 | ---- | --- | --- | --- | --- |
| A-13-01 05DDA2 | 78-08-24 | GW | ---- | 495 | ---- | --- | --- | --- | --- |
| A-13-01 06CCB | 78-08-24 | GW | ---- | 630 | ---- | --- | --- | --- | --- |
| A-13-01 06CDA | 78-03-24 | GW | ---- | 420 | ---- | --- | --- | --- | --- |

selected wells, springs, and base flow sites in Agua Fria area--Continued

| Date of sample | Hardness, noncarbonate (mg/L $CACO_3$) | Hardness noncarbonate (mg/L as $CACO_3$) | Sodium adsorption ratio | Alkalinity field (mg/L as $CACO_3$) | Alkalinity lab (mg/L as $CACO_3$) | Bicarbonate it-fld (mg/L as $HCO_3$) | Bicarbonate fet-fld (mg/L as $HCO_3$) | Carbonate fet-fld (mg/L as $CO_3$) | Chloride, dissolved (mg/L as CL) |
|---|---|---|---|---|---|---|---|---|---|
| 78-10-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-18 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-07-05 | 260 | ----- | 1.0 | 160 | --- | --- | 200 | 0 | 78 |
| 78-10-19 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-19 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-03-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-18 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-18 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-18 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-19 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 77-08-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-06-21 | 18 | ----- | .7 | 260 | --- | --- | 320 | 0 | 18 |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-14 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-13 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-13 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-11 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-03-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Calcium dis- solved (mg/L as CA) | Magne- sium, dis- solved (mg/L as MG) | Potas- sium, dis- solved (mg/L as K) | Sodium+ potas- sium, dis- solved (mg/L as NA) | Sodium, dis- solved (mg/L as NA) | Sulfate dis- solved (mg/L (as $SO_4$) | Fluo- ride, dis- solved (mg/L as F) | Silica, dis- solved (mg/L as $SIO_2$) |
|---|---|---|---|---|---|---|---|---|---|
| A-12-01 27DBA2 | 78-10-03 | ----- | ---- | ----- | --- | ----- | ----- | 0.5 | ---- |
| A-12-01 29DAC | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-12-01 31BCC | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-12-01 33AAD | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-12-01 33ADA | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-12-01 33ADB | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-12-01 34DAC1 | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-12-01 34DBB | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-12-02 08DBA | 78-10-18 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| | 79-07-05 | 120 | 29 | 1.8 | 49 | 47 | 220 | .4 | 19 |
| A-12-02 22BCD | 78-10-19 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| A-12-02 22CDC | 78-10-19 | ----- | ---- | ----- | --- | ----- | ----- | .7 | ---- |
| A-12-02 27ACB | 79-03-20 | ----- | ---- | ----- | --- | ----- | ----- | .7 | ---- |
| A-12-02 27BDA1 | 78-10-18 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| A-12-02 27BDA3 | 78-10-18 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| A-12-02 27DDB | 78-10-18 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-12-02 29ACD | 78-10-19 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-12-02 31BDD | 77-08-03 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| A-12-03 01CAC | 78-09-05 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-12-03 08BDD | 79-06-21 | 76 | 22 | 1.4 | 32 | 27 | 43 | .2 | 32 |
| A-12-03 10BAB | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| A-12-03 11BBC | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| A-12-03 17CCB | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-12-03 20BCD | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-12-03 22BBC | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| A-12-03 28DBA | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-12-03 35BAA | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| A-13-01 02DCA | 78-09-14 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-01 03ABB | 78-09-20 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-01 03ACD | 78-09-20 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-13-01 03BBC | 78-09-13 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 03BCD | 78-08-23 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 03CAA | 78-08-23 | ----- | ---- | ----- | --- | ----- | ----- | .9 | ---- |
| A-13-01 03CBA | 78-08-23 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-13-01 03DAC | 78-09-20 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-13-01 04ABA2 | 78-09-13 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-01 04BCB | 78-09-11 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-13-01 05CAB2 | 78-08-24 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 05CBA | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-13-01 05DCC1 | 78-08-24 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-13-01 05DCC2 | 78-08-24 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 05DDA1 | 78-08-24 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 05DDA2 | 78-08-24 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 06CCB | 78-08-24 | ----- | ---- | ----- | --- | ----- | ----- | .7 | ---- |
| A-13-01 06CDA | 78-03-24 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |

| Date of sample | Nitrogen, NO2+NO3 dissolved (mg/L as N) | Phosphorus, ortho, dissolved (mg/L as P) | Aluminum, dissolved (µg/L as AL) | Antimony, dissolved (µg/L as SB) | Arsenic dissolved (µg/L as AS) | Barium, dissolved (µg/L as BA) | Beryllium, dissolved (µg/L (as BE) | Boron, dissolved (µg/L as B) | Cadmium, dissolved (µg/L as CD) |
|---|---|---|---|---|---|---|---|---|---|
| 78-10-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-18 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-07-05 | 1.3 | ----- | -- | --- | --- | ---- | -- | 70 | --- |
| 78-10-19 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-19 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-03-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-18 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-18 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-18 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-19 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 77-08-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-06-21 | .21 | ----- | -- | --- | --- | ---- | -- | 50 | --- |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-14 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-13 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-13 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-11 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-03-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Chromium, dissolved (µg/L as CR) | Chromium, hexavalent, dissolved (µg/L as CR) | Cobalt, dissolved (µg/L as CO) | Copper, dissolved (µg/L as CU) | Iron, dissolved (µg/L as FE) | Lead, dissolved (µg/L as PB) | Lithium, dissolved (µg/L as LI) | Manganese, dissolved (µg/L as HG) |
|---|---|---|---|---|---|---|---|---|---|
| A-12-01 27DBA2 | 78-10-03 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 29DAC | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 31BCC | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 33AAD | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 33ADA | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 33ADB | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 34DAC1 | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-01 34DBB | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-02 08DBA | 78-10-18 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 79-07-05 | --- | -- | -- | --- | <10 | --- | -- | <1 |
| A-12-02 22BCD | 78-10-19 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-02 22CDC | 78-10-19 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-02 27ACB | 79-03-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-02 27BDA1 | 78-10-18 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-02 27BDA3 | 78-10-18 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-02 27DDB | 78-10-18 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-02 29ACD | 78-10-19 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-02 31BDD | 77-08-03 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-03 01CAC | 78-09-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-03 08BDD | 79-06-21 | --- | -- | -- | --- | <10 | --- | -- | 30 |
| A-12-03 10BAB | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-03 11BBC | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-03 17CCB | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-03 20BCD | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-03 22BBC | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-03 28DBA | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-12-03 35BAA | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 02DCA | 78-09-14 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 03ABB | 78-09-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 03ACD | 78-09-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 03BBC | 78-09-13 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 03BCD | 78-08-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 03CAA | 78-08-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 03CBA | 78-08-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 03DAC | 78-09-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 04ABA2 | 78-09-13 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 04BCB | 78-09-11 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 05CAB2 | 78-08-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 05CBA | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 05DCC1 | 78-08-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 05DCC2 | 78-08-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 05DDA1 | 78-08-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 05DDA2 | 78-08-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 06CCB | 78-08-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 06CDA | 78-03-24 | --- | -- | -- | --- | --- | --- | -- | --- |

| Date of sample | Mercury, dis-solved (µg/L as HG) | Molyb-denum, dis-solved (µg/L as MO) | Nickel, dis-solved (µg/L as NI) | Sele-nium, dis-solved (µg/L as SE) | Silver, dis-solved (µg/L as AG) | Stron-tium, dis-solved (µg/L as SR) | Vana-dium, dis-solved (µg/L as V) | Zinc, dis-solved (µg/L (as ZN) | Cyanide total (mg/L as CN) |
|---|---|---|---|---|---|---|---|---|---|
| 78-10-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 79-07-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 79-03-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 77-08-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-09-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 79-06-21 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-09-14 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-09-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-09-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-09-13 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-09-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-09-13 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-09-11 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-08-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-03-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Site | Streamflow, instantaneous ($ft^3/s$) | Specific conductance ($\mu S/cm$) | Temperature (°C) | pH (units) | Solids, residue at 180°C dissolved (mg/L) | Solids, sum of constituents, dissolved (mg/L) | Hardness (mg/L as $CACO_3$) |
|---|---|---|---|---|---|---|---|---|---|
| A-13-01 07ABA | 78-08-31 | GW | ---- | 510 | ---- | --- | --- | --- | --- |
| A-13-01 07ABB | 78-08-25 | GW | ---- | 495 | ---- | --- | --- | --- | --- |
| A-13-01 07ACA | 78-08-25 | GW | ---- | 940 | ---- | --- | --- | --- | --- |
| A-13-01 07ACD | 78-08-31 | GW | ---- | 1,120 | ---- | --- | --- | --- | --- |
| A-13-01 07ADC | 78-08-31 | GW | ---- | 1,080 | ---- | --- | --- | --- | --- |
| A-13-01 07ADC | 79-06-18 | SP | ---- | 1,100 | 18.0 | 7.4 | --- | 662 | 450 |
| A-13-01 07BBB | 78-08-24 | GW | ---- | 575 | ---- | --- | --- | --- | --- |
| A-13-01 07BCB1 | 78-08-31 | GW | ---- | 1,020 | ---- | --- | --- | --- | --- |
| A-13-01 07CAD | 78-08-31 | GW | ---- | 930 | ---- | --- | --- | --- | --- |
| A-13-01 07CDD | 78-08-25 | GW | ---- | 720 | ---- | --- | --- | --- | --- |
| A-13-01 07DAB | 78-08-31 | GW | ---- | 840 | ---- | --- | --- | --- | --- |
| A-13-01 07DBB | 79-06-18 | GW | ---- | 900 | ---- | 6.9 | --- | 472 | 330 |
| A-13-01 07DCA1 | 78-08-25 | GW | ---- | 805 | ---- | --- | --- | --- | --- |
| A-13-01 07DCA2 | 78-08-25 | GW | ---- | 1,550 | ---- | --- | --- | --- | --- |
| A-13-01 07DCC1 | 78-08-25 | GW | ---- | 720 | ---- | --- | --- | --- | --- |
| A-13-01 07DDC | 78-08-31 | GW | ---- | 900 | ---- | --- | --- | --- | --- |
| A-13-01 10AAA | 78-09-20 | GW | ---- | 485 | 17.0 | --- | --- | --- | --- |
| A-13-01 11BCA1 | 78-09-21 | GW | ---- | 490 | 17.0 | --- | --- | --- | --- |
| A-13-01 11BCA2 | 78-09-21 | GW | ---- | 590 | 15.0 | --- | --- | --- | --- |
| A-13-01 11BCB | 78-09-21 | GW | ---- | 715 | ---- | --- | --- | --- | --- |
| A-13-01 11BDB | 78-09-21 | GW | ---- | 405 | 17.5 | --- | --- | --- | --- |
| | 79-06-19 | GW | ---- | 415 | 17.0 | 8.2 | --- | 243 | 120 |
| | 81-11-11 | GW | 1.0 | --- | 18.0 | --- | --- | --- | --- |
| A-13-01 11CDB | 78-09-20 | GW | ---- | 485 | ---- | --- | --- | --- | --- |
| A-13-01 12BAA | 81-11-12 | GW | 1.0 | 435 | 20.0 | 7.9 | --- | 247 | 170 |
| A-13-01 14BCD1 | 78-10-04 | GW | ---- | 540 | ---- | --- | --- | --- | --- |
| A-13-01 14BDC | 78-10-04 | GW | ---- | 510 | ---- | --- | --- | --- | --- |
| A-13-01 14CBA2 | 78-09-20 | GW | ---- | 430 | ---- | --- | --- | --- | --- |
| A-13-01 14DDB1 | 78-10-04 | GW | ---- | 560 | ---- | --- | --- | --- | --- |
| A-13-01 18ABB | 78-08-25 | GW | ---- | 620 | ---- | --- | --- | --- | --- |
| A-13-01 18BAD2 | 78-08-25 | GW | ---- | 725 | ---- | --- | --- | --- | --- |
| A-13-01 20DDD | 78-10-20 | SP | ---- | 2,050 | 15.5 | --- | --- | --- | --- |
| A-13-01 23ABA | 78-10-05 | GW | ---- | 590 | ---- | --- | --- | --- | --- |
| A-13-01 29AAC | 78-10-20 | SP | ---- | 2,140 | 16.0 | --- | --- | --- | --- |
| A-13-01 29BDB | 78-10-20 | SP | ---- | 3,050 | 16.5 | --- | --- | --- | --- |
| A-13-01 H02AAA | 78-08-23 | GW | ---- | 890 | 20.5 | --- | --- | --- | --- |
| A-13-02 11AAA | 78-04-20 | GW | ---- | 220 | 16.5 | 7.5 | --- | 132 | --- |
| A-13-02 24ACC | 78-09-05 | GW | ---- | 650 | ---- | --- | --- | --- | --- |
| A-13-02 26CBC | 78-09-05 | GW | ---- | 720 | ---- | --- | --- | --- | --- |
| A-13-02 30DBD | 78-10-18 | GW | ---- | 2,050 | 19.5 | --- | --- | --- | --- |
| A-13-02 36DDC | 78-08-31 | GW | ---- | 600 | 23.0 | --- | --- | --- | --- |
| A-13-03 01BDC | 78-04-19 | GW | ---- | 420 | 21.0 | 7.8 | --- | 251 | 150 |
| A-13-03 33CAD | 78-09-05 | SP | ---- | 650 | ---- | --- | --- | --- | --- |
| A-13-04 18ADD | 78-04-19 | GW | ---- | 800 | 15.5 | 7.4 | --- | 480 | --- |
| A-14-01 22CAD | 78-04-26 | GW | ---- | 300 | 20.0 | --- | --- | --- | --- |

selected wells, springs, and base flow sites in Agua Fria area--Continued

| Date of sample | Hardness, noncarbonate (mg/L $CACO_3$) | Hardness noncarbonate (mg/L as $CACO_3$) | Sodium adsorption ratio | Alkalinity field (mg/L as $CACO_3$) | Alkalinity lab (mg/L as $CACO_3$) | Bicarbonate it-fld (mg/L as $HCO_3$) | Bicarbonate fet-fld (mg/L as $HCO_3$) | Carbonate fet-fld (mg/L as $CO_3$) | Chloride, dissolved (mg/L as CL) |
|---|---|---|---|---|---|---|---|---|---|
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-06-18 | 58 | ----- | 1.4 | 390 | --- | --- | 480 | 0 | 64 |
| 78-08-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-06-18 | 17 | ----- | 1.0 | 310 | --- | --- | 380 | 0 | 22 |
| 78-08-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-21 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-21 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-21 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-06-19 | 0 | ----- | 1.2 | 130 | --- | --- | 160 | 0 | 11 |
| 81-11-11 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-11-12 | --- | 21 | .7 | --- | 150 | 210 | --- | --- | 21 |
| 78-10-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-04 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-25 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-04-20 | --- | ----- | --- | 110 | --- | --- | 130 | 0 | 5.9 |
| 78-09-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-18 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-08-31 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-04-19 | 0 | ----- | .8 | 160 | --- | --- | 190 | 0 | 19 |
| 78-09-05 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-04-19 | --- | ----- | --- | 240 | --- | --- | 290 | 0 | 17 |
| 78-04-26 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Calcium dis- solved (mg/L as CA) | Magne- sium, dis- solved (mg/L as MG) | Potas- sium, dis- solved (mg/L as K) | Sodium+ potas- sium, dis- solved (mg/L as NA) | Sodium, dis- solved (mg/L as NA) | Sulfate dis- solved (mg/L (as $SO_4$) | Fluo- ride, dis- solved (mg/L as F) | Silica, dis- solved (mg/L as $SIO_2$) |
|---|---|---|---|---|---|---|---|---|---|
| A-13-01 07ABA | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | 0.8 | ---- |
| A-13-01 07ABB | 78-08-25 | ----- | ---- | ----- | --- | ----- | ----- | .9 | ---- |
| A-13-01 07ACA | 78-08-25 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-13-01 07ACD | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-13-01 07ADC | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .9 | ---- |
| A-13-01 07ADC | 79-06-18 | 120 | 37 | 0.6 | 67 | 66 | 110 | .5 | 26 |
| A-13-01 07BBB | 78-08-24 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| A-13-01 07BCB1 | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .7 | ---- |
| A-13-01 07CAD | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 07CDD | 78-08-25 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-13-01 07DAB | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 07DBB | 79-06-18 | 87 | 27 | 1.6 | 42 | 40 | 81 | .4 | 21 |
| A-13-01 07DCA1 | 78-08-25 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 07DCA2 | 78-08-25 | ----- | ---- | ----- | --- | ----- | ----- | .7 | ---- |
| A-13-01 07DCC1 | 78-08-25 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 07DDC | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 10AAA | 78-09-20 | ----- | ---- | ----- | --- | ----- | ----- | .9 | ---- |
| A-13-01 11BCA1 | 78-09-21 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| A-13-01 11BCA2 | 78-09-21 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 11BCB | 78-09-21 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-01 11BDB | 78-09-21 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| | 79-06-19 | 22 | 16 | 2.5 | 33 | 30 | 39 | .7 | 27 |
| | 81-11-11 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| A-13-01 11CDB | 78-09-20 | ----- | ---- | ----- | --- | ----- | ----- | .6 | ---- |
| A-13-01 12BAA | 81-11-12 | 42 | 16 | 1.2 | --- | 19 | 18 | .3 | 30 |
| A-13-01 14BCD1 | 78-10-04 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-13-01 14BDC | 78-10-04 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-13-01 14CBA2 | 78-09-20 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |
| A-13-01 14DDB1 | 78-10-04 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-01 18ABB | 78-08-25 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 18BAD2 | 78-08-25 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-01 20DDD | 78-10-20 | ----- | ---- | ----- | --- | ----- | ----- | 1.0 | ---- |
| A-13-01 23ABA | 78-10-05 | ----- | ---- | ----- | --- | ----- | ----- | .5 | ---- |
| A-13-01 29AAC | 78-10-20 | ----- | ---- | ----- | --- | ----- | ----- | 1.0 | ---- |
| A-13-01 29BDB | 78-10-20 | ----- | ---- | ----- | --- | ----- | ----- | 1.2 | ---- |
| A-13-01 HO2AAA | 78-08-23 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-02 11AAA | 78-04-20 | 26 | ---- | 39 | --- | 1.0 | 8.2 | .1 | 5.6 |
| A-13-02 24ACC | 78-09-05 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-02 26CBC | 78-09-05 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-02 30DBD | 78-10-18 | ----- | ---- | ----- | --- | ----- | ----- | 1.0 | ---- |
| A-13-02 36DDC | 78-08-31 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-03 01BDC | 78-04-19 | 30 | 17 | 9.9 | --- | 22 | 10 | .2 | 38 |
| A-13-03 33CAD | 78-09-05 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-13-04 18ADD | 78-04-19 | 96 | ---- | 240 | --- | 15 | 160 | .3 | 25 |
| A-14-01 22CAD | 78-04-26 | ----- | ---- | ----- | --- | ----- | ----- | .3 | ---- |

| Date of sample | Nitrogen, NO2+NO3 dissolved (mg/L as N) | Phosphorus, ortho, dissolved (mg/L as P) | Aluminum, dissolved (µg/L as AL) | Antimony, dissolved (µg/L as SB) | Arsenic dissolved (µg/L as AS) | Barium, dissolved (µg/L as BA) | Beryllium, dissolved (µg/L (as BE) | Boron, dissolved (µg/L as B) | Cadmium, dissolved (µg/L as CD) |
|---|---|---|---|---|---|---|---|---|---|
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-06-18 | 0.14 | ----- | -- | --- | --- | ---- | -- | 60 | --- |
| 78-08-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-06-18 | .96 | ----- | -- | --- | --- | ---- | -- | 40 | --- |
| 78-08-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-21 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-21 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-21 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-06-19 | 2.8 | ----- | -- | --- | --- | ---- | -- | <20 | --- |
| 81-11-11 | ----- | ----- | 10 | --- | 30 | <100 | -- | --- | <1 |
| 78-09-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-11-12 | 1.9 | 0.020 | 10 | --- | 17 | 72 | -- | 20 | <1 |
| 78-10-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-04 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-25 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-04-20 | .21 | <.010 | -- | --- | --- | ---- | -- | 90 | --- |
| 78-09-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-09-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-18 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-08-31 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-04-19 | 2.6 | .010 | -- | --- | --- | ---- | -- | <20 | --- |
| 78-09-05 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-04-19 | 2.3 | <.010 | -- | --- | --- | ---- | -- | <20 | --- |
| 78-04-26 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Chromium, dissolved (µg/L as CR) | Chromium, hexavalent, dissolved (µg/L as CR) | Cobalt, dissolved (µg/L as CO) | Copper, dissolved (µg/L as CU) | Iron, dissolved (µg/L as FE) | Lead, dissolved (µg/L as PB) | Lithium, dissolved (µg/L as LI) | Manganese, dissolved (µg/L as MG) |
|---|---|---|---|---|---|---|---|---|---|
| A-13-01 07ABA | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07ABB | 78-08-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07ACA | 78-08-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07ACD | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07ADC | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07ADC | 79-06-18 | --- | -- | -- | --- | 20 | --- | -- | 60 |
| A-13-01 07BBB | 78-08-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07BCB1 | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07CAD | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07CDD | 78-08-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07DAB | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07DBB | 79-06-18 | --- | -- | -- | --- | 90 | --- | -- | 20 |
| A-13-01 07DCA1 | 78-08-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07DCA2 | 78-08-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07DCC1 | 78-08-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 07DDC | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 10AAA | 78-09-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 11BCA1 | 78-09-21 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 11BCA2 | 78-09-21 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 11BCB | 78-09-21 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 11BDB | 78-09-21 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 79-06-19 | --- | -- | -- | --- | 20 | --- | -- | 1 |
| | 81-11-11 | <10 | 1 | -- | 1 | --- | 1 | -- | --- |
| A-13-01 11CDB | 78-09-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 12BAA | 81-11-12 | <10 | 2 | -- | 1 | <10 | 1 | -- | 9 |
| A-13-01 14BCD1 | 78-10-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 14BDC | 78-10-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 14CBA2 | 78-09-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 14DDB1 | 78-10-04 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 18ABB | 78-08-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 18BAD2 | 78-08-25 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 20DDD | 78-10-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 23ABA | 78-10-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 29AAC | 78-10-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 29BDB | 78-10-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-01 HO2AAA | 78-08-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-02 11AAA | 78-04-20 | --- | -- | -- | --- | 70 | --- | -- | 30 |
| A-13-02 24ACC | 78-09-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-02 26CBC | 78-09-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-02 30DBD | 78-10-18 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-02 36DDC | 78-08-31 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-03 01BDC | 78-04-19 | --- | -- | -- | --- | <10 | --- | -- | <10 |
| A-13-03 33CAD | 78-09-05 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-13-04 18ADD | 78-04-19 | --- | -- | -- | --- | 80 | --- | -- | 40 |
| A-14-01 22CAD | 78-04-26 | --- | -- | -- | --- | --- | --- | -- | --- |

| Date of sample | Mercury, dis-solved (µg/L as HG) | Molyb-denum, dis-solved (µg/L as MO) | Nickel, dis-solved (µg/L as NI) | Sele-nium, dis-solved (µg/L as SE) | Silver, dis-solved (µg/L as AG) | Stron-tium, dis-solved (µg/L as SR) | Vana-dium, dis-solved (µg/L as V) | Zinc, dis-solved (µg/L (as ZN) | Cyanide total (mg/L as CN) |
|---|---|---|---|---|---|---|---|---|---|
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 79-06-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 79-06-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-09-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-09-21 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-09-21 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-09-21 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 79-06-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 81-11-11 | <0.1 | --- | --- | 1 | --- | 420 | ---- | 10 | --- |
| 78-09-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 81-11-12 | <.1 | --- | --- | 1 | --- | 350 | ---- | 4 | --- |
| 78-10-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-10-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-09-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-10-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-25 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-10-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-10-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-10-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-10-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-04-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-09-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-09-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-10-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-08-31 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-04-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-09-05 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-04-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |
| 78-04-26 | ---- | --- | --- | --- | --- | --- | ---- | --- | --- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Site | Streamflow, instantaneous ($ft^3/s$) | Specific conductance (µS/cm) | Temperature (°C) | pH (units) | Solids, residue at 180°C dissolved (mg/L) | Solids, sum of constituents, dissolved (mg/L) | Hardness (mg/L as $CACO_3$) |
|---|---|---|---|---|---|---|---|---|---|
| A-14-01 22CAD | 79-06-20 | GW | ---- | 310 | 23.0 | 7.7 | --- | 196 | 130 |
| | 81-11-13 | GW | 0.00 | ----- | ---- | --- | --- | --- | --- |
| A-14-01 24DCB | 81-11-13 | GW | .00 | 360 | 21.0 | 7.9 | --- | 211 | 160 |
| A-14-01 28BCB | 71-08-13 | GW | ---- | 356 | ---- | 7.7 | --- | 232 | 160 |
| A-14-01 28CDC | 81-05-27 | GW | ---- | 390 | 19.0 | 7.4 | --- | 230 | 150 |
| A-14-01 28CDC | 81-11-10 | GW | 2.7 | ----- | 19.0 | --- | --- | --- | --- |
| A-14-01 35DDC1 | 78-09-13 | GW | ---- | 290 | ---- | --- | --- | --- | --- |
| | 79-06-20 | GW | ---- | 290 | ---- | 8.3 | --- | 213 | 9 |
| | 81-11-11 | GW | .01 | 288 | 23.0 | 8.7 | --- | --- | 10 |
| A-14-01 35DDD | 78-09-13 | GW | ---- | 345 | ---- | --- | --- | --- | --- |
| A-14-02H25CCA | 78-04-20 | GW | ---- | 700 | 14.0 | 7.6 | --- | 552 | 340 |
| A-14-03 17DDD1 | 78-03-16 | GW | ---- | 700 | ---- | 7.4 | --- | 464 | 340 |
| A-14-03 21BAD | 78-03-16 | GW | ---- | 580 | 16.0 | 6.9 | --- | 390 | 250 |
| A-15-01 01ABA | 81-02-24 | SP | ---- | 635 | ---- | --- | --- | --- | --- |
| A-15-01 10BCD2 | 81-02-24 | GW | ---- | 770 | ---- | --- | --- | --- | --- |
| A-15-01 10BCD2 | 81-05-06 | GW | ---- | 910 | 15.5 | 7.5 | --- | 518 | 350 |
| A-15-01 15CBB | 81-02-24 | GW | ---- | 1,390 | ---- | --- | --- | --- | --- |
| A-15-01 26ABC | 81-02-24 | GW | ---- | 450 | ---- | --- | --- | --- | --- |
| | 81-05-06 | GW | ---- | 555 | 18.5 | 7.5 | --- | 290 | 230 |
| A-15-01 28ACC | 81-11-10 | GW | .00 | 520 | 18.0 | 7.8 | --- | --- | 250 |
| A-15-02 02D UN | 78-04-20 | SP | ---- | 365 | 16.0 | 7.6 | --- | 276 | 230 |
| A-15-02 06BC UN | 81-02-24 | SP | ---- | 480 | 14.0 | --- | --- | --- | --- |
| | 81-05-26 | SP | ---- | 560 | ---- | 7.6 | --- | 307 | 250 |
| A-16-01 21ACA2 | 81-02-03 | GW | ---- | 510 | ---- | --- | --- | --- | --- |
| | 81-05-26 | GW | ---- | 540 | 17.0 | 7.3 | --- | 344 | 260 |
| A-16-01 27DA UN | 78-07-19 | GW | ---- | 471 | 18.5 | --- | --- | --- | 210 |
| | 81-02-24 | GW | ---- | 470 | ---- | --- | --- | --- | --- |
| | 81-05-06 | GW | ---- | 510 | 18.0 | 7.8 | --- | 266 | 210 |
| B-12-01 27ABD | 78-10-20 | GW | ---- | 1,710 | ---- | --- | --- | --- | --- |
| B-12H01 22DDC | 78-10-17 | SP | ---- | 1,100 | 15.0 | --- | --- | --- | --- |
| B-14-01 06ADD | 81-06-18 | GW | ---- | 215 | ---- | --- | --- | --- | --- |
| B-14-01 06BCB | 78-07-19 | GW | ---- | 684 | 18.0 | --- | --- | --- | 290 |
| | 81-03-12 | GW | ---- | 595 | ---- | --- | --- | --- | --- |
| | 81-05-04 | GW | ---- | 635 | 18.5 | 7.1 | --- | 372 | 280 |
| B-14-01 10ACD | 72-02-21 | GW | ---- | 412 | 19.0 | 7.6 | --- | 255 | 170 |
| B-14-01 10ACD | 81-05-27 | GW | ---- | 370 | 24.5 | 7.3 | --- | 249 | 120 |
| | 81-11-13 | GW | 3.8 | --- | ---- | --- | --- | --- | --- |
| B-14-01 10DCC | 71-10-14 | GW | ---- | 542 | 19.0 | 7.8 | --- | 354 | 240 |
| B-14-01 14ACC | 71-07-30 | GW | ---- | 486 | ---- | 7.1 | --- | 322 | 220 |
| | 81-11-13 | GW | .60 | --- | ---- | --- | --- | --- | --- |
| B-14-01 24DCC | 79-06-20 | GW | ---- | 730 | ---- | 7.2 | --- | 460 | 310 |
| B-14-02 01DCD | 80-12-23 | GW | ---- | 570 | ---- | --- | --- | --- | --- |
| | 81-05-04 | GW | ---- | 630 | ---- | 7.0 | --- | 353 | 250 |

| Date of sample | Hardness, noncarbonate (mg/L as $CACO_3$) | Hardness noncarbonate (mg/L as $CACO_3$) | Sodium adsorption ratio | Alkalinity field (mg/L as $CACO_3$) | Alkalinity lab (mg/L as $CACO_3$) | Bicarbonate it-fld (mg/L as $HCO_3$) | Bicarbonate fet-fld (mg/L as $HCO_3$) | Carbonate fet-fld (mg/L as $CO_3$) | Chloride, dissolved (mg/L as CL) |
|---|---|---|---|---|---|---|---|---|---|
| 79-06-20 | 6 | ----- | 0.7 | 120 | --- | | 150 | 0 | 9.1 |
| 81-11-13 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-11-13 | --- | 16 | .6 | --- | 140 | 200 | --- | --- | 12 |
| 71-08-13 | 3 | ----- | .5 | 157 | --- | --- | 191 | 0 | 6.9 |
| 81-05-27 | --- | 10 | .8 | --- | 140 | --- | --- | --- | 23 |
| | | | | | | | | | |
| 81-11-10 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-09-13 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 79-06-20 | 0 | ----- | 8.4 | 130 | --- | --- | 160 | 0 | 3.8 |
| 81-11-11 | --- | .00 | 8.4 | --- | 130 | 170 | --- | --- | 4.0 |
| 78-09-13 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| | | | | | | | | | |
| 78-04-20 | 19 | ----- | 1.4 | 320 | --- | --- | 390 | 0 | 36 |
| 78-03-16 | 41 | ----- | .7 | 300 | --- | --- | 370 | 0 | 23 |
| 78-03-16 | 84 | ----- | .7 | 160 | --- | --- | 200 | 0 | 17 |
| 81-02-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-02-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| | | | | | | | | | |
| 81-05-06 | --- | 83 | 1.1 | --- | 270 | --- | --- | --- | 80 |
| 81-02-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-02-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-05-06 | --- | 6.0 | .3 | --- | 220 | --- | --- | --- | 6.9 |
| 81-11-10 | --- | 19 | .4 | --- | 230 | --- | --- | --- | 24 |
| | | | | | | | | | |
| 78-04-20 | 26 | ----- | .2 | 210 | --- | --- | 250 | 0 | 3.6 |
| 81-02-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-05-26 | --- | 9.0 | .4 | --- | 240 | --- | --- | --- | 18 |
| 81-02-03 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-05-26 | --- | 47 | .5 | --- | 210 | --- | --- | --- | 29 |
| | | | | | | | | | |
| 78-07-19 | --- | ----- | .4 | 193 | --- | --- | --- | --- | 22 |
| 81-02-24 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-05-06 | --- | 11 | .4 | --- | 200 | --- | --- | --- | 6.6 |
| 78-10-20 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-10-17 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| | | | | | | | | | |
| 81-06-18 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 78-07-19 | --- | ----- | .5 | 255 | --- | --- | --- | --- | 45 |
| 81-03-12 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-05-04 | --- | 48 | .6 | --- | 230 | --- | --- | --- | 44 |
| 72-02-21 | 36 | ----- | .6 | 137 | --- | --- | 167 | 0 | 17 |
| | | | | | | | | | |
| 81-05-27 | --- | .00 | 1.3 | --- | 140 | --- | --- | --- | 15 |
| 81-11-13 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 71-10-14 | 73 | ----- | .6 | 167 | --- | --- | 203 | 0 | 18 |
| 71-07-30 | 64 | ----- | .5 | 160 | --- | --- | 195 | 0 | 11 |
| 81-11-13 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| | | | | | | | | | |
| 79-06-20 | 130 | ----- | .6 | 180 | --- | --- | 220 | 0 | 36 |
| 80-12-23 | --- | ----- | --- | --- | --- | --- | --- | --- | ----- |
| 81-05-04 | --- | 64 | .5 | --- | 190 | --- | --- | --- | 36 |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Calcium dis- solved (mg/L as CA) | Magne- sium, dis- solved (mg/L as MG) | Potas- sium, dis- solved (mg/L as K) | Sodium+ potas- sium, dis- solved (mg/L as NA) | Sodium, dis- solved (mg/L as NA) | Sulfate dis- solved (mg/L (as $SO_4$) | Fluo- ride, dis- solved (mg/L as F) | Silica, dis- solved (mg/L as $SIO_2$) |
|---|---|---|---|---|---|---|---|---|---|
| A-14-01 22CAD | 79-06-20 | 22 | 18 | 1.4 | 19 | 18 | 20 | 0.4 | 27 |
| | 81-11-13 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| A-14-01 24DCB | 81-11-13 | 47 | 9.4 | .8 | --- | 15 | 5.0 | .3 | 28 |
| A-14-01 28BCB | 71-08-13 | 46 | 11 | 1.9 | --- | 15 | 26 | .5 | 26 |
| A-14-01 28CDC | 81-05-27 | 42 | 11 | 1.8 | --- | 23 | 18 | .2 | 22 |
| A-14-01 28CDC | 81-11-10 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| A-14-01 35DDC1 | 78-09-13 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| | 79-06-20 | 3.1 | .4 | 1.2 | 60 | 59 | 9.1 | .8 | 55 |
| | 81-11-11 | 3.4 | .5 | .5 | --- | 60 | <5.0 | .7 | 56 |
| A-14-01 35DDD | 78-09-13 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-14-02H25CCA | 78-04-20 | 91 | 27 | 20 | --- | 60 | 81 | .4 | 27 |
| A-14-03 17DDD1 | 78-03-16 | 90 | 29 | 2.0 | --- | 30 | 61 | .3 | 35 |
| A-14-03 21BAD | 78-03-16 | 73 | 16 | .6 | --- | 27 | 62 | .3 | 24 |
| A-15-01 01ABA | 81-02-24 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| A-15-01 10BCD2 | 81-02-24 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| A-15-01 10BCD2 | 81-05-06 | 110 | 19 | .9 | --- | 47 | 55 | .7 | 28 |
| A-15-01 15CBB | 81-02-24 | ----- | ---- | ----- | --- | ----- | ----- | .9 | ---- |
| A-15-01 26ABC | 81-02-24 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| | 81-05-06 | 59 | 19 | .8 | --- | 11 | 15 | .2 | 32 |
| A-15-01 28ACC | 81-11-10 | 57 | 26 | 1.6 | --- | 13 | <5.0 | .2 | 24 |
| A-15-02 02D UN | 78-04-20 | 48 | 27 | 1.4 | --- | 6.4 | 31 | .1 | 31 |
| A-15-02 06BC UN | 81-02-24 | ----- | ---- | ----- | --- | ----- | ----- | .2 | ---- |
| | 81-05-26 | 52 | 29 | 2.3 | --- | 13 | 4.1 | .1 | 39 |
| A-16-01 21ACA2 | 81-02-03 | ----- | ---- | ----- | --- | ----- | ----- | .8 | ---- |
| | 81-05-26 | 60 | 26 | 2.8 | --- | 17 | 33 | .3 | 36 |
| A-16-01 27DA UN | 78-07-19 | 41 | 25 | 2.9 | --- | 12 | 11 | --- | ---- |
| | 81-02-24 | ----- | ---- | ----- | --- | ----- | ----- | .4 | ---- |
| | 81-05-06 | 45 | 24 | 2.8 | --- | 12 | 13 | .2 | 35 |
| B-12-01 27ABD | 78-10-20 | ----- | ---- | ----- | --- | ----- | ----- | 1.0 | ---- |
| B-12H01 22DDC | 78-10-17 | ----- | ---- | ----- | --- | ----- | ----- | 1.1 | ---- |
| B-14-01 06ADD | 81-06-18 | ----- | ---- | ----- | --- | ----- | ----- | 3.0 | ---- |
| B-14-01 06BCB | 78-07-19 | 80 | 21 | 1.6 | --- | 20 | 22 | --- | ---- |
| | 81-03-12 | ----- | ---- | ----- | --- | ----- | ----- | 1.5 | ---- |
| | 81-05-04 | 75 | 22 | 5.2 | --- | 22 | 23 | 1.5 | 33 |
| B-14-01 10ACD | 72-02-21 | 48 | 13 | 2.6 | --- | 17 | 48 | .3 | 23 |
| B-14-01 10ACD | 81-05-27 | 24 | 15 | 3.2 | --- | 32 | 31 | .4 | 41 |
| | 81-11-13 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| B-14-01 10DCC | 71-10-14 | 68 | 17 | 1.6 | --- | 23 | 93 | .2 | 26 |
| B-14-01 14ACC | 71-07-30 | 65 | 15 | .7 | --- | 17 | 88 | .2 | 24 |
| | 81-11-13 | ----- | ---- | ----- | --- | ----- | ----- | --- | ---- |
| B-14-01 24DCC | 79-06-20 | 96 | 18 | 1.2 | 25 | 24 | 140 | .3 | 28 |
| B-14-02 01DCD | 80-12-23 | ----- | ---- | ----- | --- | ----- | ----- | 1.8 | ---- |
| | 81-05-04 | 67 | 21 | 1.4 | --- | 20 | 39 | 1.0 | 27 |

| Date of sample | Nitrogen, NO2+NO3 dissolved (mg/L as N) | Phosphorus, ortho, dissolved (mg/L as P) | Aluminum, dissolved (µg/L as AL) | Antimony, dissolved (µg/L as SB) | Arsenic dissolved (µg/L as AS) | Barium, dissolved (µg/L as BA) | Beryllium, dissolved (µg/L (as BE) | Boron, dissolved (µg/L as B) | Cadmium, dissolved (µg/L as CD) |
|---|---|---|---|---|---|---|---|---|---|
| 79-06-20 | 1.3 | ----- | -- | --- | --- | ---- | -- | 40 | --- |
| 81-11-13 | ----- | ----- | <0 | --- | 5 | 100 | -- | --- | <1 |
| 81-11-13 | 1.7 | .020 | <0 | --- | 3 | 57 | -- | 10 | <1 |
| 71-08-13 | 1.0 | .010 | -- | --- | --- | ---- | -- | 0 | --- |
| 81-05-27 | 1.1 | .010 | -- | --- | --- | ---- | -- | 10 | --- |
| 81-11-10 | ----- | ----- | 10 | --- | 3 | <100 | -- | --- | <1 |
| 78-09-13 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 79-06-20 | .31 | ----- | -- | --- | --- | ---- | -- | 200 | --- |
| 81-11-11 | .40 | .030 | 10 | --- | 68 | 12 | -- | 260 | <1 |
| 78-09-13 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-04-20 | 3.9 | .020 | -- | --- | --- | ---- | -- | 50 | --- |
| 78-03-16 | 2.3 | .040 | -- | --- | --- | ---- | -- | 410 | --- |
| 78-03-16 | 16 | .020 | -- | --- | <1 | ---- | -- | 40 | --- |
| 81-02-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-02-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-05-06 | 3.4 | .030 | -- | --- | --- | ---- | -- | 30 | --- |
| 81-02-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-02-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-05-06 | 3.1 | .030 | -- | --- | 5 | ---- | -- | 20 | --- |
| 81-11-10 | .12 | .090 | -- | --- | --- | ---- | -- | 10 | --- |
| 78-04-20 | .91 | .040 | -- | --- | 6 | ---- | -- | <20 | --- |
| 81-02-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-05-26 | 1.1 | .030 | -- | --- | --- | ---- | -- | 70 | --- |
| 81-02-03 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-05-26 | 2.9 | .020 | -- | --- | --- | ---- | -- | 30 | --- |
| 78-07-19 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-02-24 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-05-06 | 1.5 | .030 | -- | --- | --- | ---- | -- | 20 | --- |
| 78-10-20 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-10-17 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-06-18 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 78-07-19 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-03-12 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-05-04 | 1.8 | .020 | -- | --- | --- | ---- | -- | 20 | --- |
| 72-02-21 | .78 | .000 | -- | --- | --- | ---- | -- | 20 | --- |
| 81-05-27 | .79 | .140 | -- | --- | --- | ---- | -- | 60 | --- |
| 81-11-13 | ----- | ----- | 10 | --- | 4 | <100 | -- | --- | <1 |
| 71-10-14 | 1.5 | .080 | -- | --- | --- | ---- | -- | 20 | --- |
| 71-07-30 | 1.1 | .020 | -- | --- | --- | ---- | -- | 20 | --- |
| 81-11-13 | ----- | ----- | <0 | --- | 1 | <100 | -- | --- | <1 |
| 79-06-20 | 1.7 | ----- | -- | --- | --- | ---- | -- | 40 | --- |
| 80-12-23 | ----- | ----- | -- | --- | --- | ---- | -- | --- | --- |
| 81-05-04 | 5.9 | .030 | -- | --- | --- | ---- | -- | 30 | --- |

Table 6.--Chemical analysis of water from the northern part of the

| Local identifier | Date of sample | Chromium, dissolved (µg/L as CR) | Chromium, hexavalent, dissolved (µg/L as CR) | Cobalt, dissolved (µg/L as CO) | Copper, dissolved (µg/L as CU) | Iron, dissolved (µg/L as FE) | Lead, dissolved (µg/L as PB) | Lithium, dissolved (µg/L as LI) | Manganese, dissolved (µg/L as HG) |
|---|---|---|---|---|---|---|---|---|---|
| A-14-01 22CAD | 79-06-20 | --- | -- | -- | --- | <10 | --- | -- | <1 |
| | 81-11-13 | 20 | 15 | -- | 27 | --- | 2 | -- | --- |
| A-14-01 24DCB | 81-11-13 | <10 | <1 | -- | 5 | 770 | 1 | -- | 14 |
| A-14-01 28BCB | 71-08-13 | --- | -- | -- | --- | 5 | --- | -- | --- |
| A-14-01 28CDC | 81-05-27 | --- | -- | -- | --- | 10 | --- | -- | 3 |
| A-14-01 28CDC | 81-11-10 | <10 | <1 | -- | 2 | --- | <1 | -- | --- |
| A-14-01 35DDC1 | 78-09-13 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 79-06-20 | --- | -- | -- | --- | <10 | --- | -- | <1 |
| | 81-11-11 | 40 | 75 | -- | 3 | <10 | 2 | -- | 2 |
| A-14-01 35DDD | 78-09-13 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-14-02H25CCA | 78-04-20 | --- | -- | -- | --- | <10 | --- | -- | <10 |
| A-14-03 17DDD1 | 78-03-16 | --- | -- | -- | --- | 20 | --- | -- | 40 |
| A-14-03 21BAD | 78-03-16 | --- | -- | -- | --- | 30 | --- | -- | 50 |
| A-15-01 01ABA | 81-02-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-15-01 10BCD2 | 81-02-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-15-01 10BCD2 | 81-05-06 | --- | -- | -- | --- | 60 | --- | -- | 4 |
| A-15-01 15CBB | 81-02-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| A-15-01 26ABC | 81-02-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-05-06 | --- | -- | -- | --- | 20 | --- | -- | 5 |
| A-15-01 28ACC | 81-11-10 | --- | -- | -- | --- | <10 | --- | -- | 570 |
| A-15-02 02D UN | 78-04-20 | --- | -- | -- | --- | <10 | --- | -- | <10 |
| A-15-02 06BC UN | 81-02-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-05-26 | --- | -- | -- | --- | <10 | --- | -- | 1 |
| A-16-01 21ACA2 | 81-02-03 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-05-26 | --- | -- | -- | --- | 450 | --- | -- | 4 |
| A-16-01 27DA UN | 78-07-19 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-02-24 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-05-06 | --- | -- | -- | --- | 40 | --- | -- | 3 |
| B-12-01 27ABD | 78-10-20 | --- | -- | -- | --- | --- | --- | -- | --- |
| B-12H01 22DDC | 78-10-17 | --- | -- | -- | --- | --- | --- | -- | --- |
| B-14-01 06ADD | 81-06-18 | --- | -- | -- | --- | --- | --- | -- | --- |
| B-14-01 06BCB | 78-07-19 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-03-12 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-05-04 | --- | -- | -- | --- | 10 | --- | -- | <1 |
| B-14-01 10ACD | 72-02-21 | --- | -- | -- | --- | 10 | --- | -- | --- |
| B-14-01 10ACD | 81-05-27 | --- | -- | -- | --- | 10 | --- | -- | 2 |
| | 81-11-13 | <10 | <1 | -- | 2 | --- | 1 | -- | --- |
| B-14-01 10DCC | 71-10-14 | --- | -- | -- | --- | 10 | --- | -- | --- |
| B-14-01 14ACC | 71-07-30 | --- | -- | -- | --- | 10 | --- | -- | --- |
| | 81-11-13 | <10 | <1 | -- | 3 | --- | 1 | -- | --- |
| B-14-01 24DCC | 79-06-20 | --- | -- | -- | --- | <10 | --- | -- | 6 |
| B-14-02 01DCD | 80-12-23 | --- | -- | -- | --- | --- | --- | -- | --- |
| | 81-05-04 | --- | -- | -- | --- | 10 | --- | -- | 5 |

| Date of sample | Mercury, dis-solved (µg/L as HG) | Molyb-denum, dis-solved (µg/L as MO) | Nickel, dis-solved (µg/L as NI) | Sele-nium, dis-solved (µg/L as SE) | Silver, dis-solved (µg/L as AG) | Stron-tium, dis-solved (µg/L as SR) | Vana-dium, dis-solved (µg/L as V) | Zinc, dis-solved (µg/L (as ZN) | Cyanide total (mg/L as CN) |
|---|---|---|---|---|---|---|---|---|---|
| 79-06-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-11-13 | <0.1 | --- | --- | 1 | --- | 540 | ---- | 60 | ---- |
| 81-11-13 | <.1 | --- | --- | <1 | --- | 170 | ---- | 490 | ---- |
| 71-08-13 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-05-27 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-11-10 | <.1 | --- | --- | <1 | --- | 280 | ---- | 10 | ---- |
| 78-09-13 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 79-06-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-11-11 | <.1 | --- | --- | <1 | --- | 71 | ---- | 4 | ---- |
| 78-09-13 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-04-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-03-16 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-03-16 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-02-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-02-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-05-06 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-02-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-02-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-05-06 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-11-10 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-04-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-02-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-05-26 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-02-03 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-05-26 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-07-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-02-24 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-05-06 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-10-17 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-06-18 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 78-07-19 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-03-12 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-05-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 72-02-21 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-05-27 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-11-13 | <.1 | --- | --- | 1 | --- | 310 | ---- | <10 | ---- |
| 71-10-14 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 71-07-30 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-11-13 | <.1 | --- | --- | <1 | --- | 270 | ---- | 30 | ---- |
| 79-06-20 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 80-12-23 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |
| 81-05-04 | ---- | --- | --- | --- | --- | --- | ---- | --- | ---- |

Wilson—WATER RESOURCES OF THE NORTHERN PART OF THE AGUA FRIA AREA, YAVAPAI COUNTY, ARIZ.—Arizona Department of Water Resources Bulletin 5

PREPARED BY THE U.S. GEOLOGICAL SURVEY IN COOPERATION
WITH THE ARIZONA DEPARTMENT OF WATER RESOURCES

DESCRIPTION OF MAP UNITS

| Erathem | System | Formation or member | Approximate thickness, in feet | Lithologic description | Water-bearing characteristics |
|---|---|---|---|---|---|
| CENOZOIC | QUATERNARY AND TERTIARY | Sedimentary deposits | 0-500 | Silt, clay, sand, and gravel and boulders; includes alluvial deposits at Munds Park, Mormon Lake, and Aubrey Valley and landslide deposits, and glacial moraine and outwash near San Francisco Peaks. | Well yields generally range from 5 to 50 gal/min; some wells yield about 500 gal/min near Munds Park and the Inner Basin of San Francisco Peaks. |
| | | Volcanic rocks | 0-1,000+ | Mainly basalt flows, cinder cones, and beds, and tuff beds. | In places will yield 1 to 100 gal/min to wells. |
| MESOZOIC | TRIASSIC | Chinle Formation | 0-200 | Siltstone and mudstone; some sandstone and conglomerate near base. | Generally not water bearing in the area; probably yields some water to three wells in the Slate Mountain-Cedar Ranch area. |
| | | Moenkopi Formation | 0-600 | Siltstone, mudstone, and silty sandstone; contains thin gypsum beds in northern and eastern parts of area. | Yields 1 to 20 gal/min of poor quality water to wells near Winslow; some wells in Fort Valley obtain 5 to 70 gal/min from fractured silty sandstone. |
| PALEOZOIC | PERMIAN | Kaibab Limestone | 0-380 | Sandy limestone and dolomite; chert nodules common in some beds. Includes Cretaceous sandstone in extreme southeast corner of area. | Generally above water table but yields 50 to 100 gal/min to wells near Leupp and Cameron. |
| | | Toroweap Formation | 0-375 | Cherty limestone and siltstone containing some gypsum beds in most of northwest to northern part of area; fine-grained, crossbedded sandstone in western part of Mogollon Rim-Flagstaff area. Formation present north and west of Verde Valley. | Generally not water bearing; yields less than 5 gal/min to a few wells near Grand Canyon Village. |
| | | Coconino Sandstone | 0-900 | Very fine to medium-grained, crossbedded sandstone; moderately to well cemented by calcareous and siliceous cement. | Main water-bearing unit in Mogollon Rim-Flagstaff area where it generally yields 50 to 1,000 gal/min to wells and springs. |
| | | Hermit Shale | 0-930 | Very fine grained sandstone, silty sandstone, and limestone; present only in the Grand Canyon area. | Not water bearing; acts as perching bed in places near Grand Canyon. |
| | PERMIAN AND PENNSYLVANIAN | Supai Formation: Upper member | 0-900 | Silty sandstone, very fine grained sandstone and siltstone; near Winslow upper member is mainly sandstone that grades downward into siltstone; west and southwest of Winslow, the siltstone grades laterally into very fine grained sandstone and silty sandstone interbedded with siltstone. | Yields 25 to 100 gal/min to wells and springs in the Mogollon Rim-Flagstaff and Sedona areas. |
| | | Supai Formation: Middle member | 0-300 | Alternating beds of siltstone and mudstone; contains limestone beds along eastern margin of area; locally contains sandstone and conglomerate south of Flagstaff. | |
| | | Supai Formation: Lower member | 0-1,100 | Mainly sandstone, siltstone, and limestone. Part of lower member is lithologically similar to and may be laterally equivalent to Naco Formation in extreme southeastern part of area. | |
| | PENNSYLVANIAN | Naco Formation | 0-575 | Mainly limestone and siltstone; some fine-grained, crossbedded sandstone; present near the Mogollon Rim east of Verde Valley. | Yields as much as 18,000 gal/min to springs along Mogollon Rim. |
| | | Unnamed limestone unit | 0-280 | Cherty limestone and siltstone; present in area of Hualapai Indian Reservation. | Yields about 28,000 gal/min to springs along Havasu Creek. |
| | MISSISSIPPIAN | Redwall Limestone | 0-600 | Cherty limestone and dolomite; limestone commonly contains solution cavities. | Yields as much as 2,700 gal/min to springs near the Mogollon Rim; may yield as much as 1,000 gal/min to wells in the Sedona area; probably does not contain water in most of the Grand Canyon-Williams area. |
| | DEVONIAN | Martin Formation | 0-500 | Cherty limestone and dolomite; present east and south of Hualapai Indian Reservation. | Yields 5 to 50 gal/min to springs near the Mogollon Rim; yields 50 to 100 gal/min to a few wells west of Seligman. |
| | | Unnamed limestone unit | 0-400 | Cherty limestone and dolomite; present near Hualapai Indian Reservation. | Locally yields water to springs. |
| | | Temple Butte Limestone | 0-100 | Calcareous sandstone and limestone; present in eastern Grand Canyon. | Not water bearing. |
| | CAMBRIAN | Muav Limestone | 0-700 | Mainly limestone and dolomite; some siltstone near base. Present north of Verde Valley. | Yields as much as 43,500 gal/min of water to major springs in the Grand Canyon area; yields 20 to 150 gal/min in the southern part of the Grand Canyon-Williams area. |
| | | Bright Angel Shale | 0-700 | Shale, limestone, and sandstone; present north of Verde Valley. | Generally not water bearing. |
| | | Tapeats Sandstone | 0-350 | Coarse-grained, well-cemented sandstone and conglomerate. | Yields 5 to 25 gal/min to wells south of Aubrey Valley; yields small quantities of water to springs along lower Little Colorado River. |
| | PRECAMBRIAN | Precambrian rocks | 0-200 | Mainly granite, gneiss, and schist. | Generally not water bearing. |

EXPLANATION

| | | |
|---|---|---|
| Qs | SEDIMENTARY DEPOSITS—Mainly sand and gravel | QUATERNARY AND TERTIARY |
| QTb | VOLCANIC ROCKS—Mainly basalt | QUATERNARY AND TERTIARY |
| TR | CHINLE FORMATION AND MOENKOPI FORMATION—Includes some Tertiary siltstone and gypsum | TRIASSIC |
| PIP | KAIBAB LIMESTONE, TOROWEAP FORMATION, COCONINO SANDSTONE, HERMIT SHALE, SUPAI FORMATION, NACO FORMATION, AND UNNAMED PENNSYLVANIAN LIMESTONE UNIT—Sandstone, limestone, and siltstone. Includes some Cretaceous sandstone in southeast corner of area | PERMIAN AND PENNSYLVANIAN |
| MDЄ | REDWALL LIMESTONE, MARTIN LIMESTONE, UNNAMED DEVONIAN LIMESTONE, TEMPLE BUTTE LIMESTONE, MUAV LIMESTONE, BRIGHT ANGEL SHALE, AND TAPEATS SANDSTONE—Mainly limestone | MISSISSIPPIAN, DEVONIAN, AND CAMBRIAN |
| pЄ | PRECAMBRIAN ROCKS—Mainly granite, gneiss, and schist | PRECAMBRIAN |

CONTACT—Approximately located

FAULT—Dashed where approximately located; dotted where concealed; U, upthrown side; D, downthrown side

MONOCLINE

ANTICLINE

6000 POTENTIOMETRIC CONTOUR—Shows altitude at which water level would have stood in tightly cased well in the Coconino aquifer. Long dashed where approximately located, short dashed where inferred. Contour interval 200 feet. National Geodetic Vertical Datum of 1929

GROUND-WATER DIVIDE—Approximately located

APPROXIMATE LIMIT OF AREA WHERE THE COCONINO AQUIFER IS SATURATED—West of this area, the aquifer probably is dry but may contain perched water in a few small areas

# GENERALIZED GEOLOGY OF SOUTHERN COCONINO COUNTY, ARIZONA, AND POTENTIOMETRIC CONTOURS IN THE COCONINO AQUIFER

# E X P L A N A T I O N

DISSOLVED SOLIDS, IN MILLIGRAMS PER LITER

Less than 500

500 to 1,000

1,000 to 2,000

More than 2,000

AREA IN WHICH WATER IN THE COCONINO AQUIFER IS CONFINED

4110 WELL—Number indicates dissolved-solids concentration, in milligrams per liter

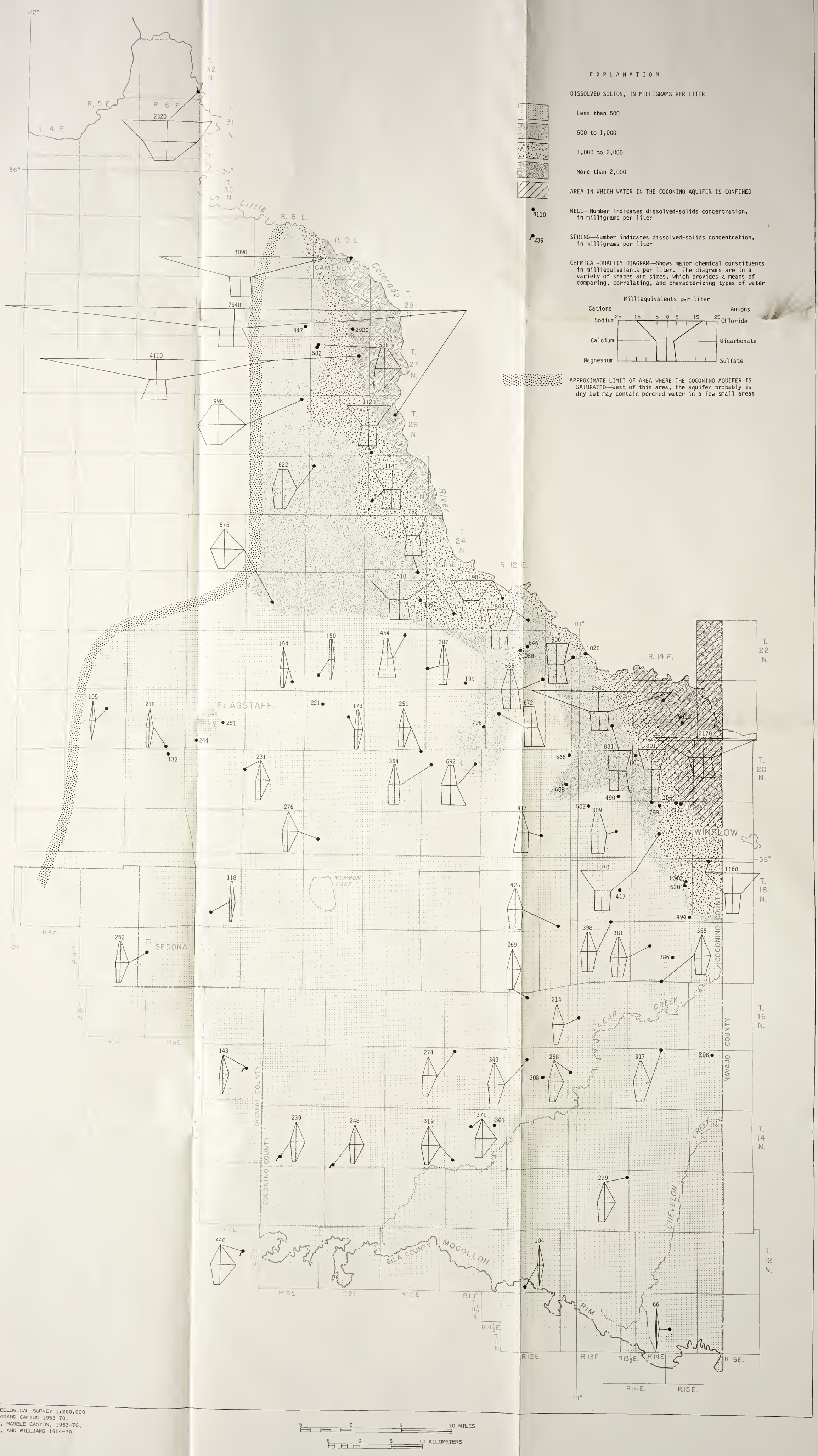
239 SPRING—Number indicates dissolved-solids concentration, in milligrams per liter

CHEMICAL-QUALITY DIAGRAM—Shows major chemical constituents in milliequivalents per liter. The diagrams are in a variety of shapes and sizes, which provides a means of comparing, correlating, and characterizing types of water

Milliequivalents per liter

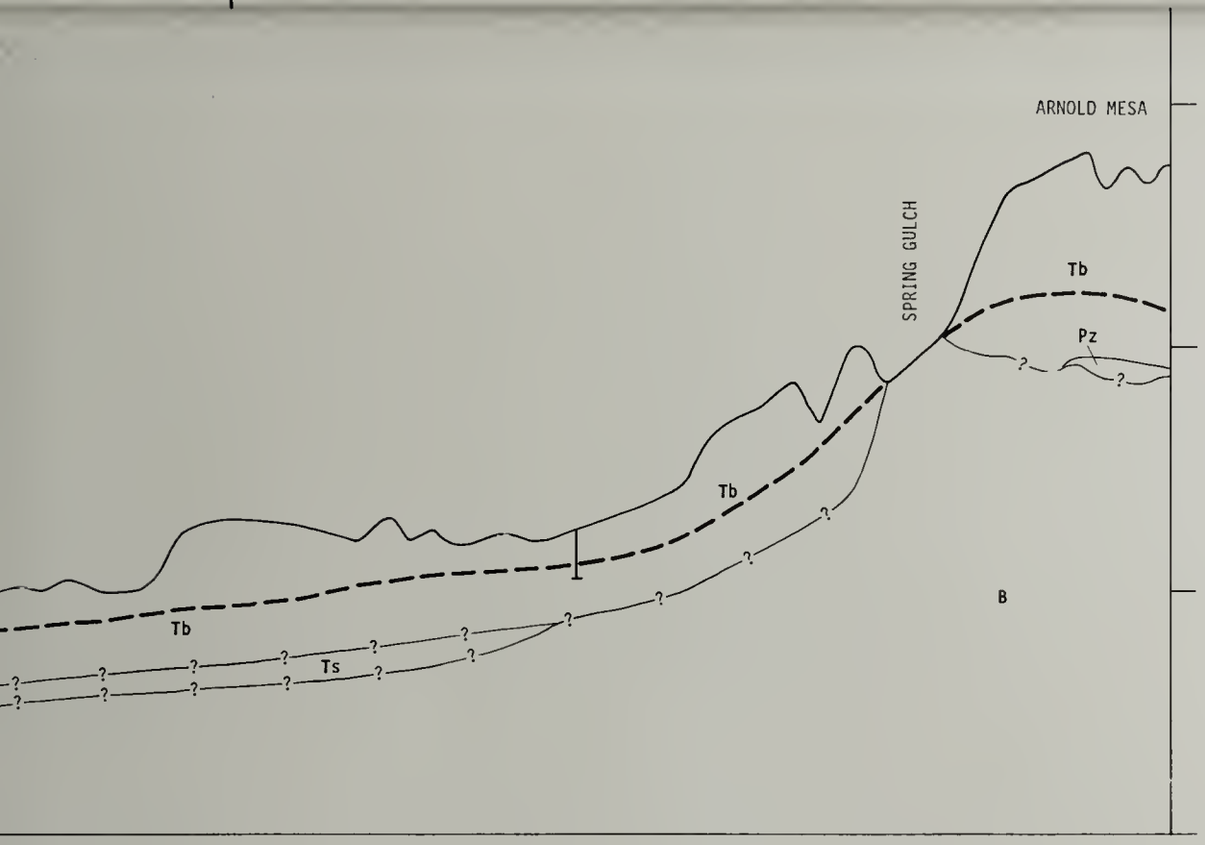
Cations Anions

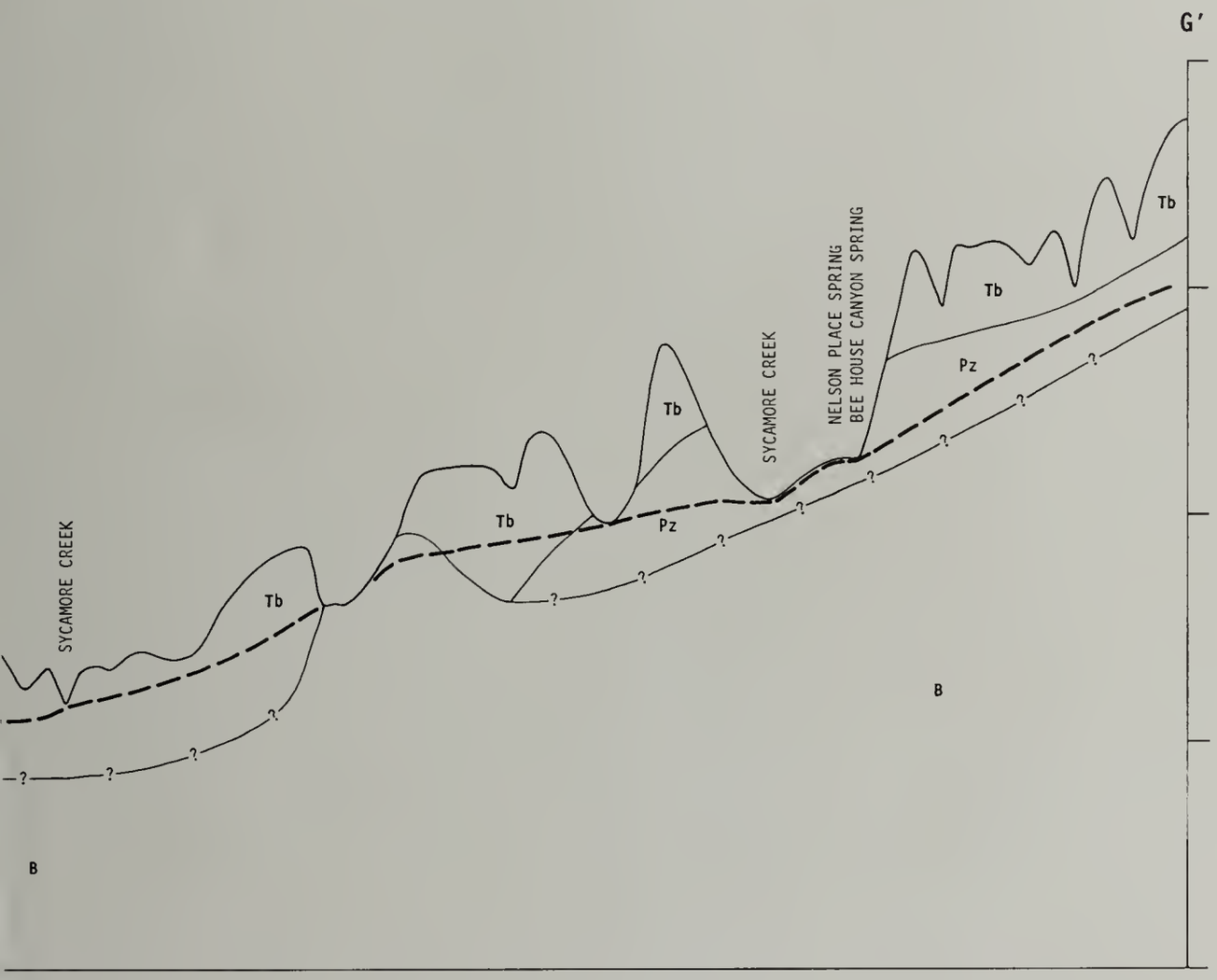
25 15 5 0 5 15 25




BASE FROM U.S. GEOLOGICAL SURVEY 1:250,000
FLAGSTAFF 1954, GRAND CANYON 1953-70,
HOLBROOK 1954-70, MARBLE CANYON, 1953-70,
PRESCOTT 1954-70, AND WILLIAMS 1954-70

# CHEMICAL QUALITY OF GROUND WATER IN THE UPPER PART OF THE COCONINO AQUIFER IN SOUTHERN COCONINO COUNTY


ARNOLD MESA
SPRING GULCH
Tb
Pz
Tb
Tb
Ts
B


G'
Tb
Tb
Pz
NELSON PLACE SPRING
BEE HOUSE CANYON SPRING
SYCAMORE CREEK
Tb
Tb
Pz
SYCAMORE CREEK
Tb
B
B

PREPARED BY THE U.S. GEOLOGICAL SURVEY IN COOPERATION
WITH THE ARIZONA DEPARTMENT OF WATER RESOURCES



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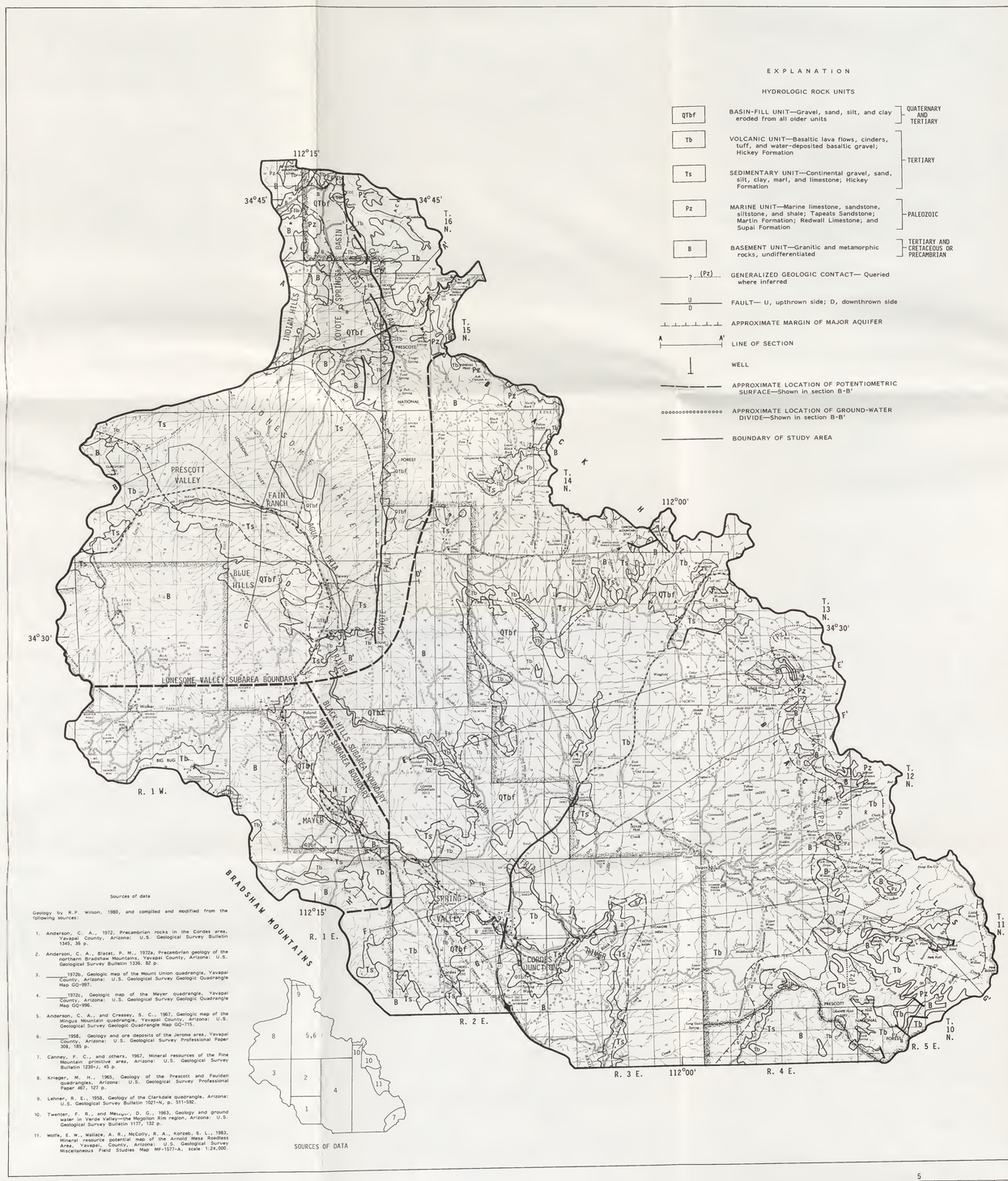



## EXPLANATION

### HYDROLOGIC ROCK UNITS

| | | |
|---|---|---|
| QTbf | BASIN-FILL UNIT—Gravel, sand, silt, and clay eroded from all older units | QUATERNARY AND TERTIARY |
| Tb | VOLCANIC UNIT—Basaltic lava flows, cinders, tuff, and water-deposited basaltic gravel; Hickey Formation | TERTIARY |
| Ts | SEDIMENTARY UNIT—Continental gravel, sand, silt, clay, marl, and limestone; Hickey Formation | TERTIARY |
| Pz | MARINE UNIT—Marine limestone, sandstone, siltstone, and shale; Tapeats Sandstone; Martin Formation; Redwall Limestone; and Supai Formation | PALEOZOIC |
| B | BASEMENT UNIT—Granitic and metamorphic rocks, undifferentiated | TERTIARY AND CRETACEOUS OR PRECAMBRIAN |

GENERALIZED GEOLOGIC CONTACT— Queried where inferred

FAULT— U, upthrown side; D, downthrown side

APPROXIMATE MARGIN OF MAJOR AQUIFER

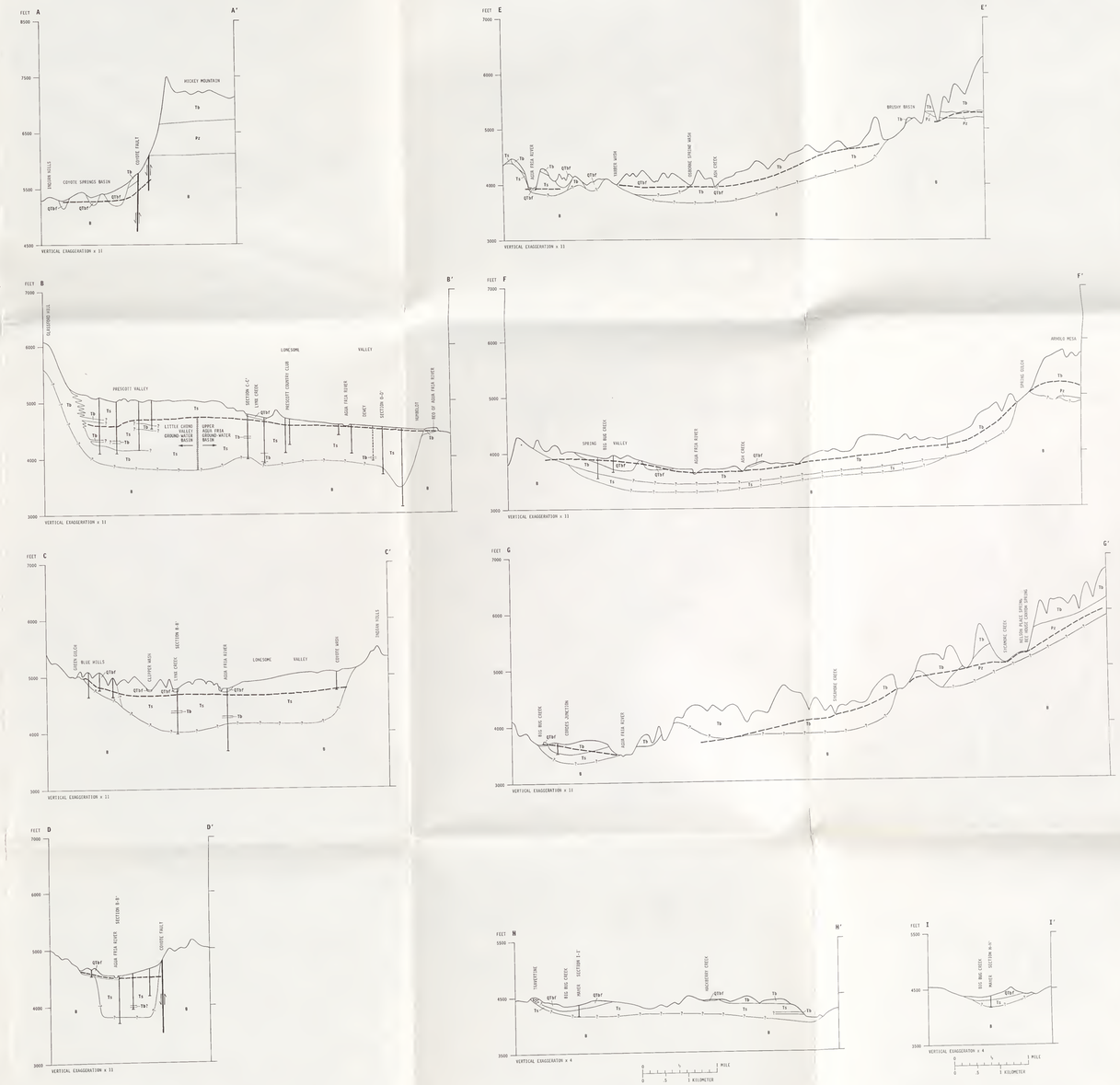
LINE OF SECTION

WELL

APPROXIMATE LOCATION OF POTENTIOMETRIC SURFACE—Shown in section B-B'

APPROXIMATE LOCATION OF GROUND-WATER DIVIDE—Shown in section B-B'

BOUNDARY OF STUDY AREA




Sources of data

Geology by R.P. Wilson, 1980, and compiled and modified from the following sources:

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2. Anderson, C. A., Blacet, P. M., 1972a, Precambrian geology of the northern Bradshaw Mountains, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1336, 82 p.
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BASE FROM ARIZONA DEPARTMENT OF TRANSPORTATION 1:126,720, 1966-68

5 0 5 MILES
5 0 5 KILOMETERS

# DISTRIBUTION OF HYDROLOGIC ROCK UNITS IN THE NORTHERN PART OF THE AGUA FRIA AREA

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BULLETIN 5
PLATE 2

LANATION

TIAL WELL YIELDS, IN GALLONS PER
ITE

10 or no data

100

1,000

o 2,000

ARY OF STUDY AREA

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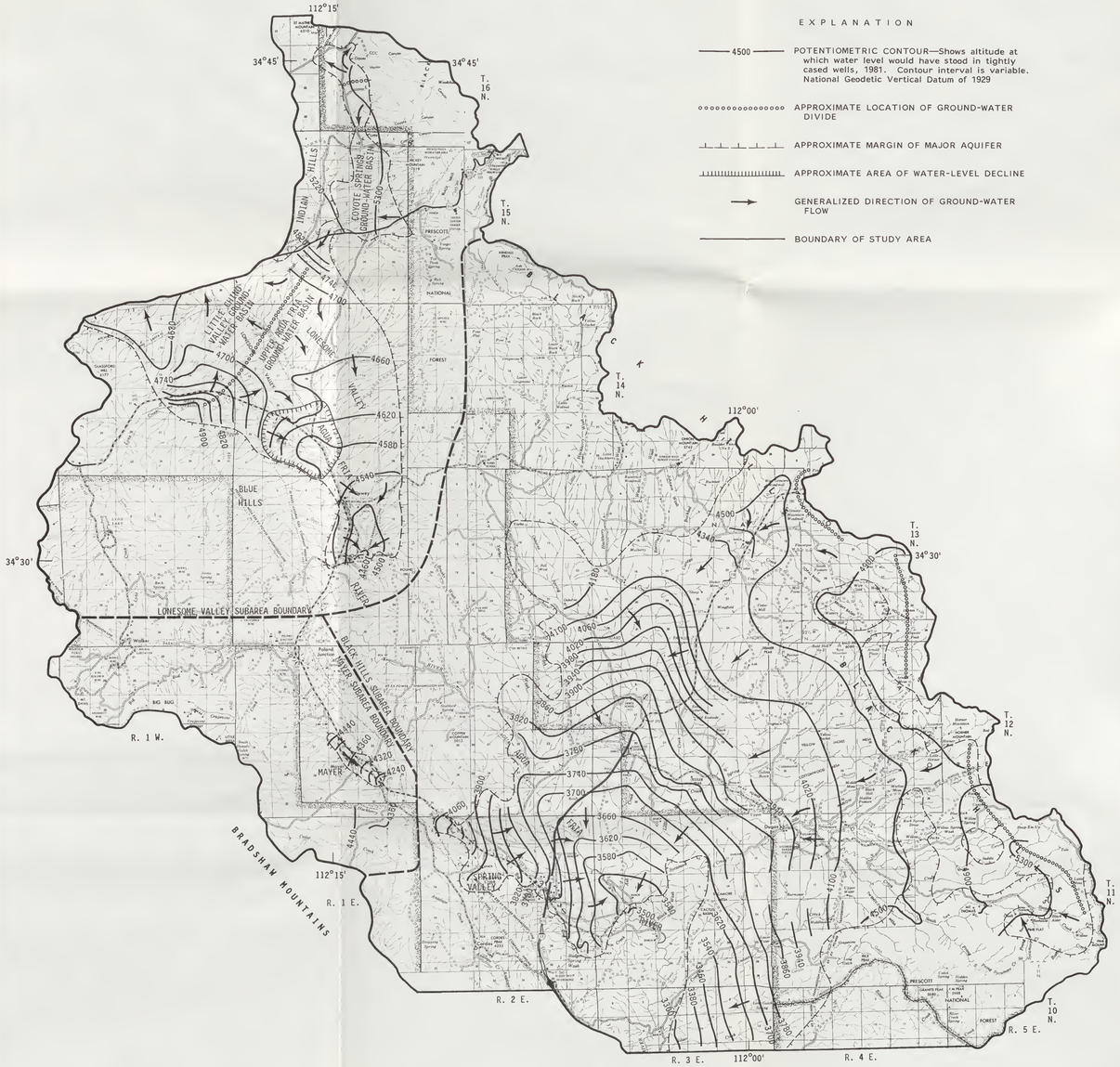



POTENTIOMETRIC SURFACE AND GENERALIZED DIRECTION OF GROUND-WATER FLOW

EXPLANATION

4500 — POTENTIOMETRIC CONTOUR—Shows altitude at which water level would have stood in tightly cased wells, 1981. Contour interval is variable. National Geodetic Vertical Datum of 1929

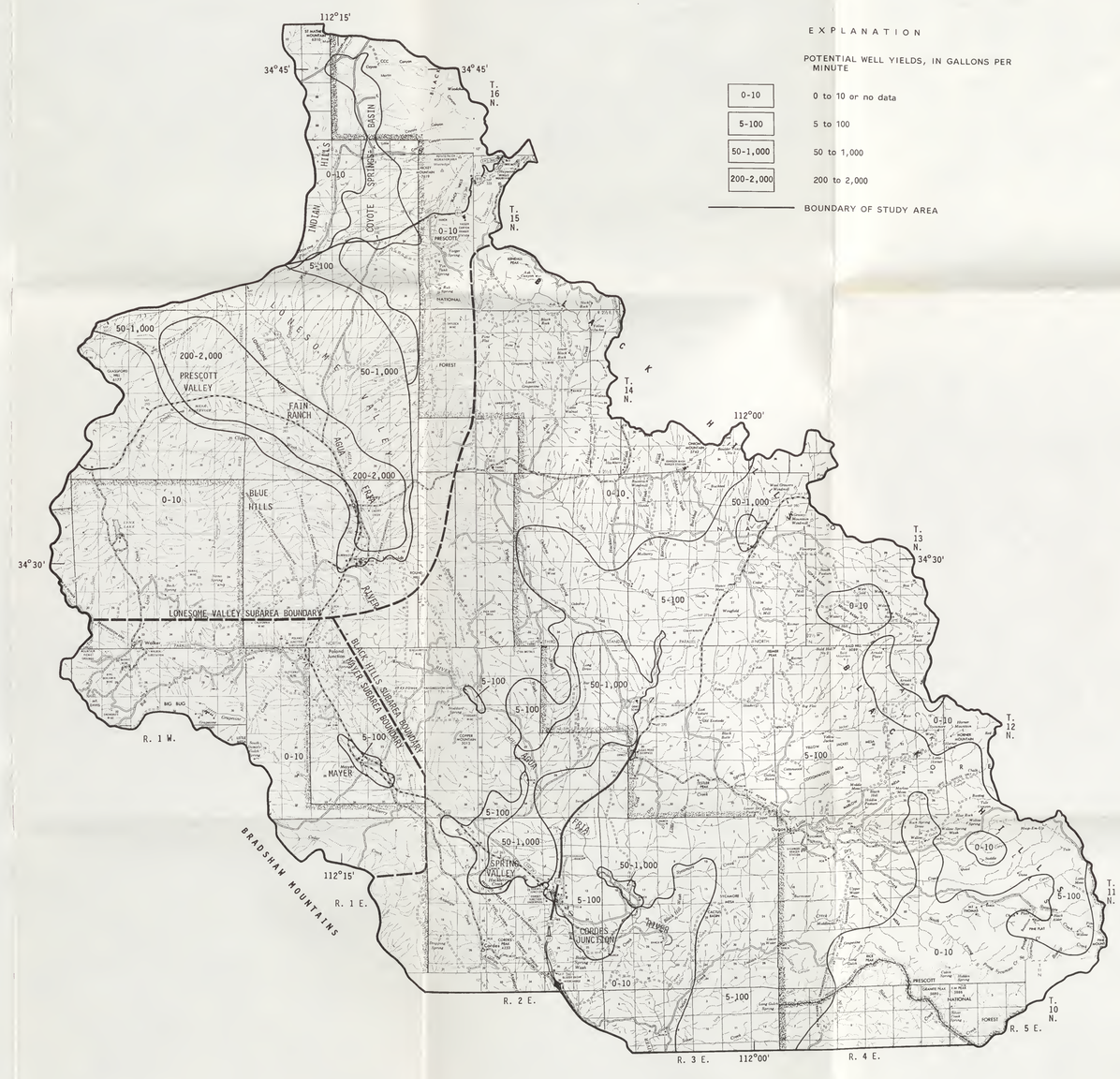
APPROXIMATE LOCATION OF GROUND-WATER DIVIDE

APPROXIMATE MARGIN OF MAJOR AQUIFER

APPROXIMATE AREA OF WATER-LEVEL DECLINE

GENERALIZED DIRECTION OF GROUND-WATER FLOW

BOUNDARY OF STUDY AREA




POTENTIAL WELL YIELDS

EXPLANATION

POTENTIAL WELL YIELDS, IN GALLONS PER MINUTE

| | |
|---|---|
| 0-10 | 0 to 10 or no data |
| 5-100 | 5 to 100 |
| 50-1,000 | 50 to 1,000 |
| 200-2,000 | 200 to 2,000 |

BOUNDARY OF STUDY AREA

BASE FROM ARIZONA DEPARTMENT OF TRANSPORTATION 1:126,720, 1966-68

5 0 5 MILES

5 0 5 KILOMETERS

# POTENTIOMETRIC SURFACE AND GENERALIZED DIRECTION OF GROUND-WATER FLOW AND POTENTIAL WELL YIELDS IN THE NORTHERN PART OF THE AGUA FRIA AREA

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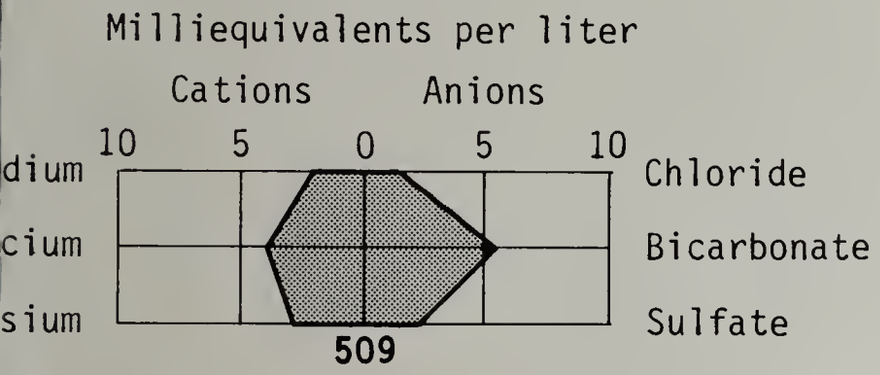
PLANATION

MICAL-QUALITY DIAGRAM—Shows major emical constituents in milliequivalents per er. The diagrams are in a variety of apes and sizes, which provide a means comparing, correlating, and characterizing pes of water. Number, 509, is dissolved ids in milligrams per liter




E-FLOW SAMPLING SITE—Number, 7, responds to tables 2 and 6. Base-flow sites re sampled during November and December 1980

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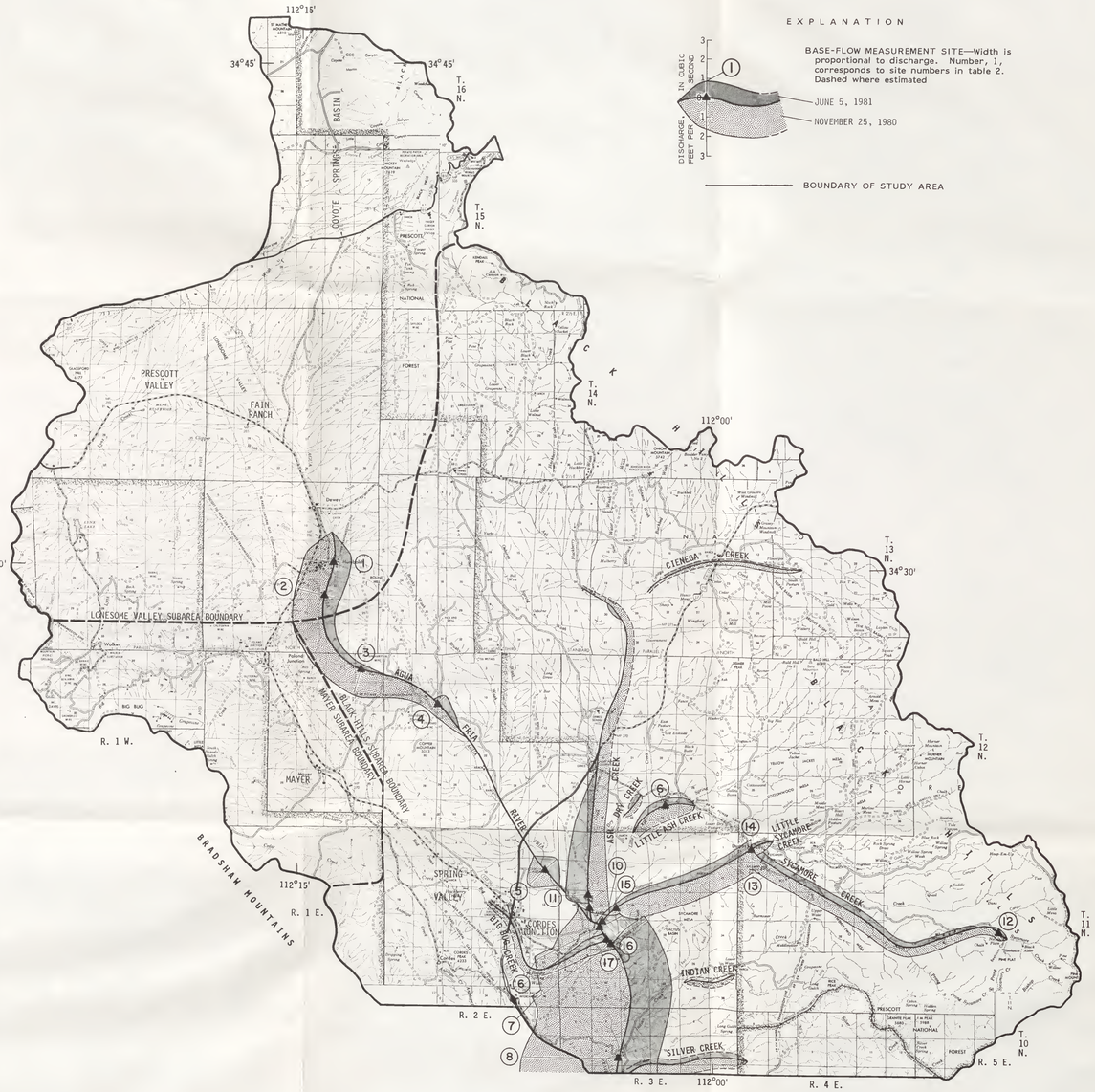



BASE FLOW OF AGUA FRIA RIVER AND TRIBUTARIES DURING THE 1981 WATER YEAR

EXPLANATION

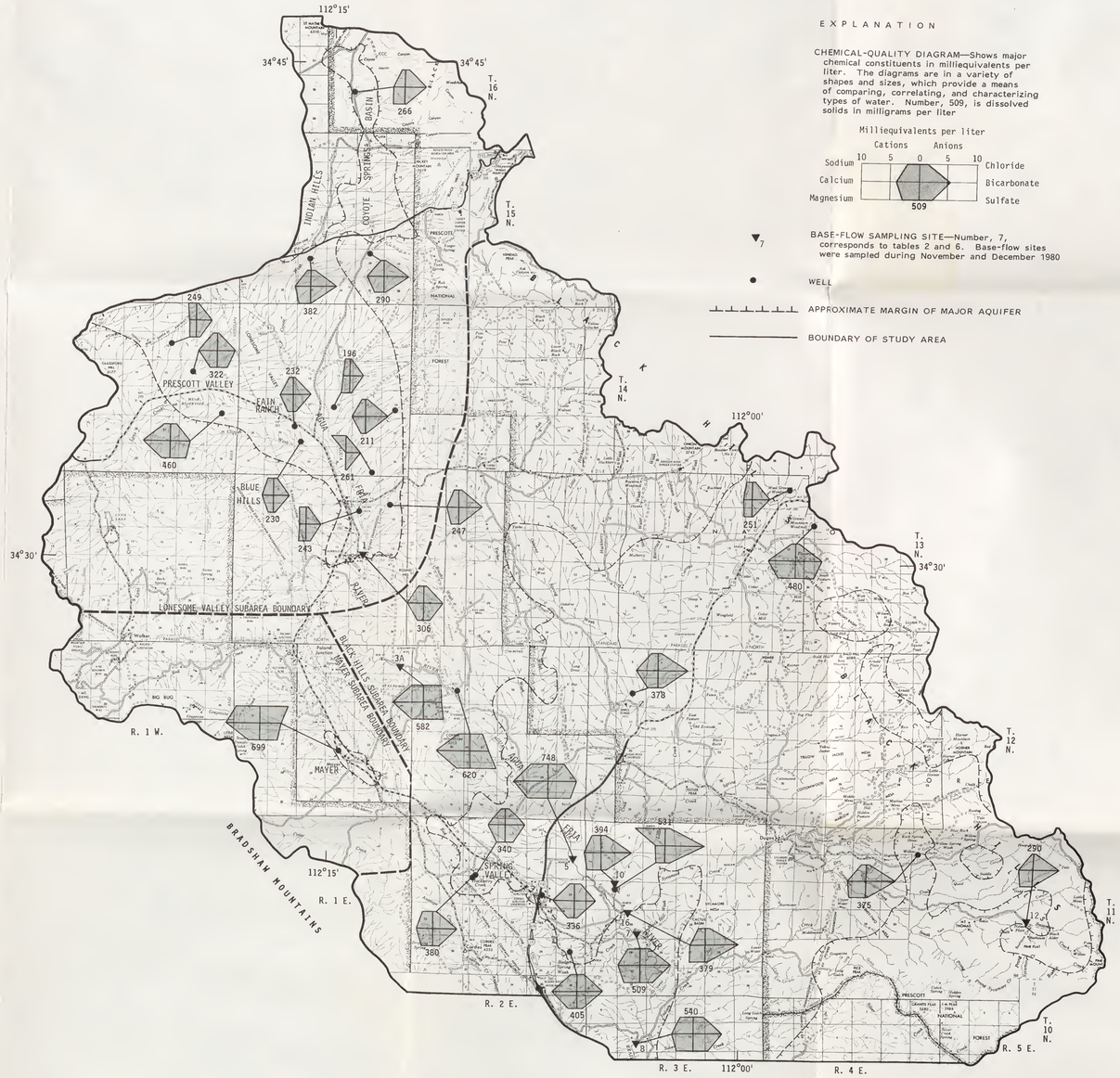



BASE-FLOW MEASUREMENT SITE—Width is proportional to discharge. Number, 1, corresponds to site numbers in table 2. Dashed where estimated

JUNE 5, 1981

NOVEMBER 25, 1980

BOUNDARY OF STUDY AREA




CHEMICAL QUALITY OF GROUND WATER AND BASE FLOW OF STREAMS

EXPLANATION

CHEMICAL-QUALITY DIAGRAM—Shows major chemical constituents in milliequivalents per liter. The diagrams are in a variety of shapes and sizes, which provide a means of comparing, correlating, and characterizing types of water. Number, 509, is dissolved solids in milligrams per liter




BASE-FLOW SAMPLING SITE—Number, 7, corresponds to tables 2 and 6. Base-flow sites were sampled during November and December 1980

WELL

APPROXIMATE MARGIN OF MAJOR AQUIFER

BOUNDARY OF STUDY AREA

BASE FROM ARIZONA DEPARTMENT OF TRANSPORTATION 1:126,720, 1966-68

5 0 5 MILES

5 0 5 KILOMETERS

# BASE FLOW OF THE AGUA FRIA RIVER AND TRIBUTARIES DURING THE 1981 WATER YEAR AND CHEMICAL QUALITY OF GROUND WATER AND BASE FLOW OF STREAMS IN THE NORTHERN PART OF THE AGUA FRIA AREA

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